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A STUDY OF DUST SUPPRESSANTS IN ONTARIO

VOLUME 2

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A STUDY OF DUST SUPPRESSANTS IN ONTARIO

Volume 2

Report prepared for:

The Ontario Ministry of the Environment and Energy
Waste Management Branch

by

CH2M HILL ENGINEERING LTD.
2000 Argentia Road, Suite 100, Plaza 3
Mississauga, Ontario
L5N 1V9

August 1993

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Calcium Chloride

REVIEW PARAMETER LIST FOR CALCIUM CHLORIDE

A. GENERAL INFORMATION

Two calcium chloride products are used for dust suppression. These are:

- Liquid calcium chloride.
- Flake/powdered calcium chloride.

Calcium chloride is also used as tire ballast, road de-icer, for cement dehydration or accelerating, cement set, as an iron ore additive, or for waste treatment.

Calcium chloride in both forms can be applied to surfaces for dust suppression. Liquid calcium chloride is a colourless, clear to slightly turbid water solution without odour. It can be produced in a solution of 20 to 45 percent calcium chloride ($CaCl_2$). The Ontario Ministry of Transportation requires that calcium chloride solutions to be used for dust suppression contain a minimum of 35 percent (mass) calcium chloride at 15 °C (Ontario Provincial Standard Specification 2501-1, December, 1983).

Flake/powdered calcium chloride is in the form of small, white, odourless flakes that are deliquescent (i.e. will dissolve in moisture absorbed from the atmosphere). The flakes are chemically represented as $CaCl_2.2H_2O$ (77 percent $CaCl_2$ by weight) and has the chemical name calcium chloride dihydrate.

SUPPLIER/DISTRIBUTOR INFORMATION

Manufacturer and Supplier Information

General Chemical Canada Ltd.
201 City Centre Drive
Mississauga, Ontario
L3B 3A3

Telephone: (416) 566-2909
Contact: Mr. Carl Bauslaugh

Calcium chloride is manufactured and distributed by General Chemical.

Applicator/Contractor Information

General Chemical can provide information on contractors and applicators. Mr. Jim Baxter in Mississauga at (416) 898-9595 is suggested as a contact.

COST INFORMATION

General Chemical charges $160 per metric tonne of flake (FMT)[1], or per 2,200 L of 35 percent solution (equivalent to 1 FMT) (1991 prices).

The applicator pays General Chemical to transport the product to their storage, adding an additional $27 to $50 per metric tonne, depending on the distance transported from General Chemical, situated in Windsor, Ontario.

The cost to the purchaser includes $6 to $20 per FMT (1991) for application, depending on the distance from the applicator's storage, the length of road to be treated, and the contractor.

Final 1991 costs range from $200 to 280 per FMT, depending on the region and contractor. Based on typical application rates and frequencies, this equates to $0.09 to $0.55 per square metre per season.

SAFETY PROCEDURES

The following safety procedures for the handling of liquid and flake calcium chloride are recommended by General Chemical.

Personal Protection

1. Operators should wear chemical safety goggles and a hard hat when handling dry flake or solutions of calcium chloride with a reasonable chance of eye contact (such as when manually filling tanks). In addition, under these conditions contact lenses should not be worn.

2. Operators should wear a long sleeved shirt, trousers, impervious boots, gloves, and apron under normal operating conditions and if there is a chance of contact with solution. Cotton gloves are permitted for flake product.

3. Operators should wear NIOSH[2]-approved mist-respirator (these should not contain metals corrodible by calcium chloride solution) for dusty or misty conditions.

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1 FMT is defined as a flake equivalent metric tonne (a metric tonne flake) or 22 liquid tonnes of 35 percent solution, equal 10 t of 77 percent flake

2 National Institute for Occupational Safety and Health

Emergency First Aid

First aid procedures are listed in the attached MSDS.

Storage Requirements

Liquid calcium chloride should not be stored in metal containers that can be corroded by the solution (such as galvanized iron containing zinc). Containers should be kept closed and protected from physical damage.

Flake calcium chloride should be stored in a cool, dry place. It should be kept covered to minimize atmospheric moisture contact. It is recommended that where possible, the flake should be inside a permanent structure. Proper drainage facilities should exist to contain any runoff. The dry salt should sit on a pad of concrete (treated with an anti-spalling material - linseed oil and mineral spirits) or asphalt. Pads must also be sloped more than 1° and less than 5° for adequate water runoff (Salt Institute, 1980).

Transportation and Shipping Requirements

Flake calcium chloride may be shipped from the manufacturer in bags, tonne sacks, and bulk via rail or trailer transport. Bulk transportation should be covered to prevent loss of product.

Liquid calcium chloride is sold in bulk by General Chemical and is transported via tanker truck, rail, or ship.

Spill Procedures

In accordance with Part 9, Section 79 of the Environment Protection Act, a spill is defined as any discharge, intentional or unintentional, of material from its containing unit beyond the recommended maximum application rate into the natural environment. This can be caused by spray bars left on after operation, tank rupture, tank turnover, etc. In the event of a spill the following procedures are recommended:

1. The spill should be isolated and contained as best possible.

2. The regional office of General Chemical and General Chemical Manufacturing at (519) 736-2111 in Sarnia should be notified after the spill has been contained.

3. All Provincial and Federal Agencies as required by law are to be notified immediately. Operators should call:

    - The Ontario Spills Action Centre at 1-800-268-6060.

- The municipality in which the spill occurred.

- Environment Canada at The Ontario Regional Environmental Emergencies line: (416)-973-1059, or (416)-346-1971 (cellular).

SOURCE DESCRIPTION AND QUALITY CONTROL

Calcium chloride is formed by the reaction of ammonium chloride (NH_4Cl) and milk of lime. This forms a calcium chloride and salt solution. Solid impurities are "settled out" in primary settlers and pumped to waste beds. The clarified calcium chloride solution is evaporated to a specific concentration in evaporators to effect the precipitation of sodium chloride (NaCl) and other less soluble salts, which are extracted from the slurry by centrifuge. At this point, liquid calcium chloride is concentrated to a 20 to 45 percent solution and is ready for shipping. The liquid calcium chloride destined for flake product is sent to a concentrator that removes additional water, producing a 73 percent calcium chloride solution at high temperatures (over 170 °C). The hot solution is cooled in a drum flaker to produce flakes, which are sent to a rotary dryer to remove additional water. The final flake product is 77 to 80 percent calcium chloride.

The following are quality control tests are performed by General Chemical:

1. Liquid and flake calcium chloride are assayed using volumetric and EDTA titration methods to determine the concentration of calcium chloride, taking into account the presence of calcium sulphate, calcium carbonate, and calcium hydroxide.

2. The bulk density of flake calcium chloride is determined via gravimetric methods.

3. Magnesium and alkali salts in calcium chloride are determined using gravimetric methods in all grades of solid calcium chloride.

4. Calcium hydroxide, calcium carbonate, and total alkalinity in calcium chloride are determined via titrametric methods.

B. TECHNICAL EFFECTIVENESS AND APPLICATION PROCEDURES

TECHNICAL EFFECTIVENESS

Calcium chloride is used both as a dust suppressant, and as a road stabilizer to help reduce potholing and prepare the road for further construction and improvement. It works as dust suppressant by:

- Attracting and holding moisture to the road surface.

- Binding the smaller particles to the surface to prevent them from becoming airborne when driven over.

Information on the technical effectiveness of calcium chloride as a dust suppressant and road stabilizer, was compiled from two sources of information; a telephone survey of current users in Ontario, and a literature review of field tests and surveys. The surveys identified in the literature were conducted by provincial, Canadian and U.S. road agencies and the mining industry.

Calcium chloride's effectiveness, as with all dust suppressants, is a function of weather, traffic volume and weight, soil composition and method of application. In a survey of municipal road agencies across Canada plus two U.S. road agencies, calcium chloride applied as a road stabilizer was found to reduce potholing, corrugations, and the need for grading compared to not treating the road (Public Works Canada, 1983). However, it has been shown that grading a road treated with calcium chloride will reduce the dust suppressing effectiveness of the palliative.

A northern Saskatchewan field study evaluated the effects of grading on the effectiveness of calcium chloride as a dust suppressant and road stabilizer (Saskatchewan, 1972). The study indicated that grading to maintain road quality reduced the dust controlling ability of calcium chloride on treated roads. Grading after rainfall lessened the negative effect, compared to grading without moisture.

A Public Works Canada survey (1983) found that calcium chloride worked better in climates with higher humidities (more than 50 percent), as both a dust suppressant and road stabilizer, whereas dryer areas required more frequent applications. Unlike the Canada wide survey, which reported humid conditions as optimal for effective results for calcium chloride treatment, a survey of dust suppressants used on U.S. mining haul roads (Steen, 1983) found calcium chloride to be used in the drier climates across the U.S., but not limited to any particular geography.

Rainfall has been shown to affect the performance of calcium chloride. It was reported in the Public Works Canada survey (1983), as well as a British Columbia Ministry of Environment survey (British Columbia, 1981), that calcium chloride contributed to slippery road conditions during periods of rainfall. The British Columbia study also reported that calcium chloride's effectiveness varied throughout the Province and had a tendency to leach away under heavy rainfall. Field studies conducted in the steel industry found that calcium chloride will have a greater tendency to leach away from roads with compact sandy soils under rainy conditions (Midwest Research Institute, 1987).

The effective dust control period of calcium chloride on municipal roads has been reported to range from 2 to 3 months in most areas across Canada (Public Works Canada, 1983). This period was confirmed in a telephone survey of representative calcium chloride users in Ontario conducted for this study. Longer effective periods up

to 2 years, have been reported for some less frequently travelled roads, such as northern logging roads. At one industrial area in Ontario, where calcium chloride was applied, its effectiveness lasted only 2 days, largely due to of heavy traffic weight and volume.

According to representative Ontario users, calcium chloride is generally not used in high traffic load conditions (industrial areas), since under these conditions it loses its dust controlling ability relatively quickly. The Midwest Research Institute's 1987 study of dust suppressants used on roads in the steel industry reported that calcium chloride is not commonly used in the steel industry and does not exhibit a control lifetime similar to that of other dust suppressants under those heavy traffic conditions.

Calcium chloride is a popular dust suppressant in Ontario because it is effective on most road surfaces. However, the results from the telephone survey carried out in this studies indicated that users at a horse arena having a surface mixture of sand and woodchip do not use calcium chloride because it provides inadequate dust control for this surface. In addition, soils with a significant content of sand, silt, or lack of mineral content (dirt) were less suitable for calcium chloride application. In a field test conducted in Newfoundland (Brown, 1989), calcium chloride was sprayed on 6.7 km of road to test the effect on road stabilization and dust control. Road compositions were not tested in detail, but were graded roughly according to: good gradable gravel, high silt content with sand, and sandy. Results showed that calcium chloride did not bind the sandy-silt material as well as it did the gravel sections, and that more potholes formed in this section. Also, the road stabilizing result for the sandy soil section, although satisfactory, was below the results obtained for the gravel sections. The study concluded that roads should contain 10 to 15 percent fine materials of clay or mineral fill (not sand) for calcium chloride to be an effective treatment.

A field test on three surface coal mine haul roads in the U.S. was carried out to determine the effectiveness of several dust suppressants on unpaved mine haul roads (PEDCO, 1983). Road surface materials were graded prior to the study. Composition ranged from 73 percent silt content at one site, to 7 and 23 percent at the other two sites. The study found that roads treated with calcium chloride with the higher silt contents (more than 23 percent) became very muddy, and rutted easily during wet weather, due to the high percentage of fines. The author concluded that with road surfaces containing too much surface silt (greater than 25 percent) no suppression program will be effective and the road should be rebuilt. This study also showed that topical applications of calcium chloride provided superior dust control over mixed-in applications in dry weather. However, mixed-in applications will survive periods of rain better than the topical applications since topical applications have a greater tendency to runoff during rainfall.

A study conducted in Southern Ontario provided a general comparison of calcium chloride's dust suppressant effectiveness compared to other dust suppressants (Acres, 1988). Stationary measurements of dust emitted from the treated road surface were taken over a three month period. These results demonstrated that dust emissions from the calcium chloride site were only three percent more than from a site treated with industrial waste oil, which was the best performer in the group. Measurements of dust emitted from the road taken from a moving surface was also carried out in this study. Results of the mobile air quality monitoring indicated that, overall, calcium chloride was one of the best palliatives for dust control.

Summary of Overall Effectiveness

The effectiveness of calcium chloride is influenced by several factors, including:

1. Maintenance grading of roads treated with calcium chloride will reduce dust control effectiveness.

2. For municipal gravel roads (<300 ADT), calcium chloride applications are most effective where relative humidity exceeds of 50 percent.

3. Periods of high rainfall will make roads treated with calcium chloride unusually slippery, muddy, and will cause the calcium chloride to leach out of the surface, thus reducing the effective period of dust suppression. More porous sandy surfaces will be more greatly affected.

4. Typically, for municipal roads, calcium chloride applications will have an effective life of about 2 to 3 months.

5. The period of effectiveness of calcium chloride is shortened in areas that have heavy traffic loads, such as in industrial yards and mines.

6. Surfaces treated with calcium chloride with too much silt (greater than 15 percent) may become very slippery, and rut easily during periods of rainfall.

7. Soils with a high sand content have been found to prevent binding and may require more frequent calcium chloride applications. No quantitative data was presented in the literature.

8. Calcium chloride has been found to work most effectively when the fines content of the surface material is below 12 to 15 percent. A level of fines higher than this will prevent binding of the surface and will increase the incidence of potholing.

9. Topical application of calcium chloride may be more effective in controlling dust than mixed-in applications in drier periods. However, mixed-in applications may prove to be a more effective method of treatment in wetter periods, because a greater resistance to leaching and runoff of the calcium chloride is provided.

APPLICATION PROCEDURES

Site Restrictions

According to the Ontario Ministry of Environment's Draft Guidelines for the Application of Dust Suppressants, dust suppressants should not be applied to sites closely adjacent to or crossing waterway(s) or marshes, or near wells.

Surface Preparation and Application Procedures

A general methodology for the application of calcium chloride in both the liquid and flake form, based on a compilation of literature provided by General Chemical, is presented below:

1. Proper drainage should be provided for the yard, or on both sides of the road.

2. The surface should be graded to a significant depth (20 to 50 mm) to remove pot holes, corrugations and other ruts. If the road is deeply rutted or corrugated it may require scarification between 25 and 100 mm.

3. Gravel or fines should be added as required, to yield a final composition of 10 to 15 percent fines (< 200 mesh) (UMA Engineering Ltd., 1987).

4. The road should be shaped to the correct crown (about 4% straight line) using a grader equipped with a straight flat blade.

5. If flake calcium chloride is being applied, the surface should first be sufficiently moistened with water so that when the soil is squeezed with the hand and let go it does not separate. This is especially important during dry periods.

6. The calcium chloride (liquid or flake) should be applied at desired levels while the surface is still moist.

7. The surface may be modestly moistened after application of flake product.

8. If the road or surface is being constructed, compaction of the surface is suggested to provide a firm solid base.

Length of Time Before and After Precipitation

Application of calcium chloride should be made while the road surface is still moist/ damp. Usually, this is about 6 to 12 hours after a significant rainfall, depending on the time of year. Application should be made 12 to 24 hours before the next rainfall, depending on humidity, to permit curing and hardening of the surface, and to prevent leaching and runoff.

Application Equipment

Application equipment guidelines for provincial transportation agencies vary significantly. Although not adopted in Ontario, British Columbia offers the most comprehensive guidelines for application equipment (UMA Engineering Ltd., 1987). The equipment recommended for application of liquid calcium chloride in B.C. are:

- Truck tanker size should not be less than 18,000 litres for liquid calcium chloride delivery, unless limited by narrow or steep roads.

- A pressurized distributor for application of liquid products with at least the following equipment:
  - a quick opening gate in the dome
  - a dipstick calibrated in 10 mm increments with calibration chart
  - an external readily visible depth gauge with 50 litre accuracy.

- Rear mounted spray bars and nozzles 0.6 to 3.6 m wide capable of:
  - vertical and lateral adjustment
  - producing double coverage in one pass.

- Spray bars that do not extend into the lane of opposing traffic unless adequate warning measures are taken

- The feed to the spray bars equipped with:
  - recirculation before and during operation
  - filters.

- Spray nozzles:
  - fitted with instant on/off valves, and,
  - which yield fan-shaped sprays without atomization

- A pressure pump capable of applying a minimum of 120 litres of material per minute per meter spray bar.

- An operator visible 15 kPa pressure gauge.

- An operator visible flow meter.

- An operator visible fifth wheel tachometer calibrated in meters per minute.

Flake calcium chloride can be distributed by a spreader of any type that will ensure uniform application in controlled strip widths and application rates. A tachometer or rate control system as described above is considered necessary equipment. This should be applied on a moist surface immediately after balding.

Personnel Requirements

Typically, two to four people are required for safe application of dust suppressant. This would consist of at least one, maybe two, flag persons and/or operator of a pilot warning vehicle the application truck operator, and a checker (the flag person can double as this person).

Dilution

Liquid calcium chloride is not normally diluted. Flake calcium chloride can be mixed with water to form a liquid solution, if desired. The water should be clear with no visible suspended particles.

Calcium chloride can be mixed with sodium chloride, but this will have a slightly negative effect on the performance as a dust suppressant (Saskatchewan, 1972). Calcium chloride should not be mixed with any other liquids, particularly bromine trifluoride, or a mixture of boron trioxide and calcium oxide, since a violent reaction with result.

Application Rate and Frequency

In most municipalities across Ontario, calcium chloride is applied at least once and usually twice per season. Drier seasons may warrant three applications of the product. Applications rates vary from 0.5 to 5.0 L/m^2 of 35 percent calcium chloride (Techman Engineering Ltd., 1982) depending on carryover of the previous years product, climatic conditions, and surface conditions/compositions.

The first application rates in the season may range from as low as 0.5 L/m^2 to as much as 1.3 L/m^2, according to General Chemical (1991). For non-industrial road treatment, subsequent application is in late summer/early fall and is generally suggested to be two thirds of the initial value.

Studies have shown that the mixed in applications of calcium chloride will remain effective for longer periods of time than topical applications in wetter weather because of a greater ability to resist leaching. However, topical applications are more effective in dry weather (PEDCO, 1983).

Typical application rates for flake calcium chloride are from 1.0 to 3.8 tonnes/km, or from 0.44 kg/m^2 to 0.8 kg/m^2 for the first application. Subsequent applications are also suggested to be about two thirds of the initial value. Industrial applications will be as needed.

British Columbia's Ministry of Transportation and Highway Maintenance suggest the following application rates (UMA Engineering Ltd., 1987):

	35 Percent Liquid Calcium Chloride	Flake Calcium Chloride
Roads Never Before Treated	1.65 L/m^2	1.00 kg/m^2
Option 1: Previously Treated Roads		
First application of any year.	1.00 L/m^2	0.60 kg/m^2
Further annual application (same year).	0.50 L/m^2	0.30 kg/m^2
Option 2: Previously Treated Roads		
Single annual application only.	1.25 L/m^2	0.75 kg/m^2

Ponding should be avoided during application. It is important to note that ponding can occur at or below the maximum application rates. Ponding will depend on several factors: the rate of liquid calcium chloride discharge, the speed of the application truck, and the porosity of the surface materials. Ponding can be prevented by shutting off the spray bars when the vehicle/truck is stopped or is passing over paved/sealed portions of the road. Care should also be taken to ensure that the liquid is applied at or below the suggested rates. If ponding still occurs then a decrease in the application rate is necessary.

Curing Time

Traffic may be allowed onto the road immediately after calcium chloride application. Curing time (12 to 24 hours) depends on relative humidity and ambient temperature after application.

Problems/Hazards

Roads treated with calcium chloride may be slippery after a period of rain.

C. PHYSICAL AND CHEMICAL CHARACTERISTICS

PHYSICAL PROPERTIES

The physical characteristics of liquid and flake calcium chloride are presented below in Table 1. The table represents values relative to 35 percent solution by weight. Other solution concentrations ranging from 20 to 45 percent by weight are also available from General Chemical.

Table 1
Physical Properties of Calcium Chloride

Property	Liquid Calcium Chloride (35%)	Flake Calcium Chloride (77%)
Odour	odourless	odourless
Appearance and colour before application	clear and slightly turbid	small white flakes, hygroscopic
Physical state when applied	liquid	flake/solid
Physical state when dry	solid	solid
pH	neutral to slightly alkaline	neutral to slightly alkaline
Solubility in water	complete	97.7 g/100 mL @ 0 ^{o}C 326 g/100 mL @ 60 ^{o}C
Vapour pressure	1.1 kPa	1.0 kPa
Melting point	-7 ^{o}C	176 ^{o}C
Boiling point	116 ^{o}C	NA
Relative viscosity	5	-
Density	1,340 kg/m^{3} @27 ^{o}C	NA

NA: Not available
Source: General Chemical Calcium Chloride MSDS sheet.

COMPONENTS AND CHEMICAL PROPERTIES

The main constituents of calcium chloride (35 percent solution) are typically (General Chemical of Canada leaflet):

Calcium chloride	-	35%
Alkali chlorides	-	1.1%
Calcium hydroxide	-	0.04%
Water	-	63.9%
		100%

One sample of liquid calcium chloride was provided by General Chemical and split for duplicate analyses of conventional parameters, metals and anions (chloride and sulphate). Analyses were carried out by CANVIRO Analytical Laboratories Ltd. Average results for the duplicate samples are presented in Table 2.

Table 2
Chemical Characteristics of Calcium Chloride

	Units	Study Sample[1] Concentration
Conventional Parameters		
pH	mg/L	8.8
Total Solids	mg/L	492,500
BOD_5	mg/L	<300
Ammonia-N	mg/L	<500
Total Phosphorus	mg/L	0.10
Oil & Grease	mg/L	<1.0
Chloride	mg/L	307,500
Sulphate	mg/L	<148
Metals		
Aluminum	mg/L	<0.05
Boron	mg/L	7.48
Barium	mg/L	25.85
Beryllium	mg/L	0.065
Cadmium	mg/L	0.034
Calcium	mg/L	133,000
Chromium	mg/L	0.045
Cobalt	mg/L	0.105
Copper	mg/L	0.18
Iron	mg/L	1.485
Lead	mg/L	<0.1
Magnesium	mg/L	21.35
Manganese	mg/L	0.065
Vanadium	mg/L	2.44
Zinc	mg/L	0.16
Nickel	mg/L	0.04
Silver	mg/L	<0.02
Strontium	mg/L	30.9
Sodium	mg/L	2,667
Arsenic	mg/L	<0.05
Selenium	mg/L	<0.01
Mercury	mg/L	<0.001

Notes:

1. Average of duplicate analyses of calcium chloride (35% solution) from General Chemical Ltd.

< Below the detection limit

The sample analyzed had a total solids concentration of 37 percent by weight. Calcium and chloride results indicated a solution strength of 32.9 percent calcium chloride. Several metals were detected in the solution, including a few above concentrations of 1 mg/L (boron, barium, iron, vanadium and strontium).

D. TOXICITY AND SUB-LETHAL EFFECTS

ACUTE TOXICITY

B.A.R. Environmental conducted duplicate acute toxicity tests on the same sample of 32.9 percent calcium chloride solution provided by General Chemical for chemical analysis. LC50 values, and their corresponding 95 percent confidence interval were measured for the test species, rainbow trout and Daphnia magna. The LC50 is the median lethal concentration (i.e. the concentration of the test chemical in water that is estimated to be lethal to 50 percent of the test organisms within a prescribed period of time). The results of the toxicity tests for calcium chloride are presented in Table 3.

According to one rating system (IMCO/FAO/UNESCO/WMO, 1969), calcium chloride toxicity rates a Grade 0, on a scale of 0 to 4, meaning it is "practically non-toxic".

Table 3
Acute Toxicity of Calcium Chloride to Rainbow Trout and Daphnia magna

Substance	Organism	Length of Test Period (h)	Effect	Concentration (mg/L)	95% Confidence Interval (mg/L)
Calcium Chloride	Rainbow Trout	96	LC50	14,857	12,440 - 17,742
	Daphnia magna	48	LC50	6,387	5,273 - 7,736

Other Acute Toxicity Information

Anhydrous calcium chloride is moderately toxic to mammals, with an oral rate toxicity of 1,000 mg/kg (Calcium Chloride MSDS).

The MSDS indicates that the chemical compound calcium chloride in solution at a concentration of 500 mg/L is harmful to aquatic life. Based on the solution strength of 32.9 percent calcium chloride the study sample, lethal calcium chloride concentrations were 4,900 mg/L[3] for rainbow trout and 2,100 mg/L[3] for Daphnia magna, compared to harmful concentrations of 500 mg/L.

In a study on the environmental impacts of calcium chloride, it was reported that chloride levels exceeding 4,000 mg/L were harmful to pike, bass and perch, and calcium chloride levels up to 12,000 mg/L and 22,000 mg/L could be tolerated by pickerel and white fish, respectively (School of Public Health, 1982). Chloride levels in the calcium

[3] Rainbow trout 32.9% (14,857 mg/L) = 4,889 mg/L, Daphnia magna 32.9% (6,387 mg/L) = 2,101 mg/L

chloride solution analyzed for this study were 3,400 mg/L at the lethal concentration to rainbow trout[4].

SUB-LETHAL EFFECTS

Limited information is available on the sub-lethal effects of liquid and flake calcium chloride. Therefore, this information was supplemented with available information on the sub-lethal effects of those contaminants found in the study sample above guidelines and objectives for drinking water and aquatic life, as presented in Table 4.

Table 4
Comparison of Contaminant Limits for Drinking Water and Aquatic Life to Concentrations in Calcium Chloride

Parameter	Aquatic Life	Drinking Water	Calcium Chloride (35% Solution)
Chloride (mg/L)	N/A	250[2]	307,500
Phosphorus (µg/L)	20 (algal growth)[2]	N/A	100
Barium (µg/L)	N/A	1,000[2,3]; 100[5]	25,850
Boron (µg/L)	N/A	5,000[2,3]	7,480
Cadmium (µg/L)	0.2[2]	5[2,3]	34
Calcium (mg/L)	N/A	No need to set numerical guidelines[5]	133,000
Iron (µg/L)	300[2]	300[2,3]	1,485
Magnesium (mg/L)	N/A	No need to set numerical guidelines[6]	21.35
Sodium (mg/L)	N/A	200[4]	2,667

Notes:

1. Only parameters with concentrations exceeding referenced limits are presented.
2. Ontario Ministry of the Environment, 1984. Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.
3. Health and Welfare Canada, 1987. Canadian Guidelines for Drinking Water Quality.
4. World Health Organization, 1984. Guidelines for Drinking Water Quality, Volume 2 Health Criteria and other supporting information.
5. U.S.S.R. Cited from W.H.O. literature.
6. Health and Welfare Canada. 1991, Personal Communication.

It is important to note that comparing the concentrations of toxic substances in 100 percent strength of the dust suppressant product provides an indication of toxicity to human and aquatic life only on a "worst case" basis. Some dilution effects will occur once the material is released to land and exposed to the effects of runoff, leaching and

[4] Rainbow trout: 307,500 mg Cl^-/L x (14,857 mg)/L / 1,340 g = 3,400 mg Cl^-/L

degradation. In addition, concentration of persistent substances after repeated application may also occur. The exact extent of dilution or build-up will depend largely on site specific factors and will not be addressed in generic assessments of sub-lethal effects.

In the absence of a detailed exposure and risk assessment, it is not possible to completely assess the degree of human or environmental health risk posed by calcium chloride use. The following discussion attempts only to identify the contaminants of concern which could potentially cause problems over the long term. In many cases, the toxological data available is limited.

Major Components

Calcium is relatively nontoxic to animals including humans. A safe intake level for calcium can be as high as 2.3 g/d (WHO, 1984). It has been reported that a 30 percent calcium chloride solution can be injurious on contact to the eyes or skin. The threshold limit value guideline for mist is 30 mg/m^3 (Calcium Chloride MSDS, 1989).

The concentration of sodium contaminants is very high in the calcium chloride product tested, and sodium salts are very soluble in water. Ill effects to sodium sensitive individuals due to high levels of sodium in drinking water have been documented. However, these effects should not be a concern under normal dust suppressant use.

The major cationic components of calcium chloride were found in small quantities except calcium and sodium. The main environmentally significant characteristic of calcium chloride is its extremely high water solubility giving rise to highly mobile ions of calcium, magnesium, and sodium. High ionic strength waters resulting from runoff have the potential to cause salt-effect damage to vegetation and increase in salinity of receiving waters. High level of salts such as sodium in water may create salinity problems to fresh water biota.

While it has been stated that calcium chloride may adversely affect aquatic species, no documentation was found to indicate these effects have occurred from the use of calcium chloride as a dust suppressant on roads. In fact, aquatic biota would be much more tolerant to most metal contaminants in the presence of calcium and magnesium.

Calcium is absorbed into vegetation and is generally beneficial to plant life. Chloride is also absorbed in small amounts, but can be toxic at very low concentrations. Chloride toxicity to plants is variable, depending on plant type, resistance, nutrient balance and season. Effects on plants exposed to soil salts include reduction in growth, leave browning, premature fall colouring, twig and branch dieback and in some species, death.

No guidelines exist for soil concentrations of chloride. Roadside grasses were reportedly not affected when soil chloride concentrations were 2,650 to 4,900 mg/kg, as a result of road deicing and dust suppressant applications (Acres, 1988). Trees like sugar and red maple tolerate chloride soil levels up to 2,000 mg/kg, while white poplar and red oak can tolerate up to 6,000 mg/kg. Grasses tend to be much more tolerant of chloride than trees (Salt Institute, 1971).

Metals

A number of metals exceeded the relevant guidelines slightly; however, only a few of these might be of human or environmental concern. Cadmium, iron and barium, for example are not likely to be of concern unless ingested in massive amounts. Cadmium may also bioaccumulate in aquatic animals and plants if high concentrations in surface waters are maintained. However, toxic or sublethal effects to aquatic biota are unlikely to be a problem if care is taken not to apply calcium chloride in the immediate vicinity of surface water.

SUMMARY

The following main points summarize the acute toxicity and sub-lethal effects of calcium chloride solution and flake:

- The acute toxicity (LC50) of calcium chloride solution to rainbow trout (96 h) was measured to be 14,857 mg/L of 32.9 percent solution. The acute toxicity (LC50) to Daphnia magna was measured to be 6,387 mg/L.

- Anhydrous calcium chloride is moderately toxic to mammals, with an oral LD50 of 1,000 mg/kg for rats.

- Calcium present in calcium chloride solutions has no relevant sub-lethal effects and will be beneficial to vegetation. Furthermore, aquatic species are more tolerant to metals in the presence of calcium.

- Chloride present in soils negatively affects vegetation growth and germination, depending on the tolerance of the species and the soil concentration. Chloride produces an undesirable taste at high levels in drinking water (250 mg/L).

- Several metals were present in 35 percent calcium chloride solution at levels slightly above guidelines and objectives for drinking water and aquatic life. These metals are not likely to cause toxic or sub-lethal effects under normal dust suppressant use.

E. ENVIRONMENTAL IMPACTS

MAIN COMPONENTS OF DUST SUPPRESSANT

Two physical processes are involved in the movement of calcium chloride through the biosphere. These include the rate and extent of migration of the hydrated salt, and the factors which govern the concentration of the dissociated ions at any given distance from the application site. The latter is discussed under the following heading.

Calcium chloride applied to unpaved surfaces absorbs moisture from the surface and/or the atmosphere, and penetrates the road surface to bind soil particles. Trapped moisture resists evaporation, and the treated surface remains damp even in hot weather. Calcium chloride does not crystallize and accumulate on the road surface, and therefore, air dispersion of salt is minimal (School of Public Health, 1982).

Calcium chloride moves through the environment with water, and this movement is dependent on the amount of precipitation, drainage and chemical and physical properties of the soil. Because it is associated with water, it will move deeper into the soil during wet periods, and return back to the road surface during dry periods.

Although vertical movement has been shown to occur somewhat, lateral movement occurs at a much lower rate. In one study, 23 percent of the original amount of calcium chloride remained at a depth of 38 cm after 55 months on a sandy clay surface, but only 4.1 percent was found in the shoulder 60 cm from the road (Ogden, 1976). In the Acres (1988) study, chloride levels in the treated road materials were 3 to 4 times higher than in ditch materials, and were 2 to 4 times higher in the first 10 cm depth than in the 10 to 20 cm range.

With significant rainfall, or where there are high drainage rates (eg. steep slopes, impervious soil, or porous soil) calcium chloride moves with water as surface runoff or soil leachate. In these conditions, the constituent ions, Ca^{2+} and Cl^{-} dissociate and migrate through the environment (School of Public Health, 1982).

COMPONENT BASED ASSESSMENT

To evaluate the environmental impacts of calcium chloride application, impacts of each of the major components, as well as those contaminants identified in Table 2, were reviewed. These included:

- Calcium
- Chloride
- Sodium
- Metals

Calcium

The calcium ion is readily absorbed by soil particles, and the amount of adsorption is dependent on soil type. Properties that affect adsorption include the organic and clay content, soil particle size, exchangeable ions present, bulk density, etc.

The calcium ion readily replaces ions such as sodium and hydrogen on soil particles. Furthermore, in the presence of high calcium concentrations, magnesium, barium, mercury, copper and lead may also be replaced, and released into soil water and surface runoff (School of Public Health, 1982).

Chloride

The monovalent, negatively charged chloride ion (Cl^-) essentially remains in solution and moves readily through the environment with water.

The environmental impacts of chloride as result of dust suppressant application have not been studied. However, impacts have been reviewed extensively with respect to road deicing (Salt Institute, 1971; School of Public Health, 1982). These effects of chloride migration could be extrapolated to dust suppression and include (Salt Institute, 1971):

- Trees along deiced road ways are less vigorous than on untreated roadways.

- Surface water collects chloride ions contained in runoff. Studies have shown that chloride levels have increased in surface waters in the vicinity of road deicing to varying levels, depending on dilution effects. Chloride concentrations in major rivers in the State of Maine increased an average of 5 to 9 mg/L from headwaters to river mouths in a two year study period, with the greatest increase occurring where roads were the most dense. The Salt Institute reports that water drainage entering large water systems were not seriously affected by chloride concentrations resulting from deicing. It has been estimated that the chloride concentration in Lake Erie has risen about 2 mg/L from the year 1910 to 1964 because of road deicing.

- Wells have also been reported to be contaminated by road deicing with salts. The pollution of well water is not usually due to groundwater contamination, but from concentrated surface runoff intrusion into the wells.

The amount of chloride applied to roadways for dust suppression is estimated to be one third of that applied for road deicing annually.

In surface waters chloride can react with mercury, released from bottom sediments in the presence of calcium. The soluble form of mercury that results is then available for uptake by aquatic biota (School of Public Health, 1982).

Sodium

Sodium is an undesirable contaminant in water from aquifers and surface water, as well as in soil. Sodium is a problem in the soil solution as a component of total salinity, which at varying levels creates toxicity problems for adsorption. Sodium is also of interest in drinking water, since sodium restricted diets are often recommended to address human health concerns.

Sodium salts have a very high solubility coefficient, meaning they are readily dissolved in rain water, making sodium one of the more mobile components of calcium chloride solution (Acres, 1990). The quantity of sodium applied to roads by application of calcium chloride solution for dust suppression is several orders of magnitude lower than the amount released by standard winter road salting practices.

Metals

None of the metals analyzed in the study sample of 35 percent calcium chloride solution were present at levels greater than the guidelines and objectives levels for soils. In a study for the Ontario Ministry of the Environment (Acres, 1988), metals studied in calcium chloride were lower than crustal abundance concentrations. Furthermore, levels in treated road surface materials, road ditch materials and site vegetation near the treated site, did not exceed the crustal abundance.

Summary

The following points summarize the environmental impacts of calcium chloride used as a dust suppressant:

- Calcium chloride moves through the environment with water, and therefore, it will move deeper into the soil during wet periods, and return back to the surface in dry periods.

- During significant rainfall or where there are high drainage rates, calcium chloride will dissociate into constituent ions and will move with surface runoff or leachate.

- Calcium does not generally migrate extensively, as it becomes adsorbed to soil particles. This adsorption may release more readily exchangeable ions such as mercury, copper and lead.

- Literature on the effects of chloride as a result of dust suppression was not identified. Literature focuses on road deicing, where the amount of chloride applied to roads is approximately 3 times higher than for dust suppression. Environmental impacts of chloride from road deicing include:

  - Increase in river and lake chloride concentrations, reported to be not significant.

  - Increase in chloride levels in well water supplies, as a result of surface contamination rather than aquifer contamination.

  - Creating the potential for solubilization of mercury from bottom sediment in surface waters.

- Sodium present in calcium chloride solution is a very mobile ion that will migrate with runoff and groundwater. The levels of sodium applied in calcium chloride application are several orders of magnitude less than for road deicing.

- One study has shown that heavy metals applied to roads from calcium chloride applications did not significantly increase the background levels of these metals at the application site.

F. OTHER IMPACTS

The use of calcium chloride as a dust suppressant has carried with it some potentially negative side effects (Brown, 1989; Acres, 1988). Complaints are often made about the following:

- Acceleration of corrosion on vehicles travelling on salted roads.

- Exposed leather will dry and become stiff, cracked, or even brittle.

- Scaling and deterioration of pavement, roads and bridges (Salt Institute, 1971).

- Slipperiness of road surfaces during periods of rain.

General Chemical

Product Safety Data Sheet

LIQUID CALCIUM CHLORIDE

A. PRODUCT INFORMATION

TRADE NAME (PRODUCT IDENTIFIER):
LIQUID CALCIUM CHLORIDE

CHEMICAL NAME AND/OR SYNONYM:
Calcium Chloride Solution

FORMULA: 20-45% $CaCl_2$ Solution

CAS NO:
10043-52-4 (annydrous)

PRODUCT USE:
Deicer, dust control, mud drilling lubricant, freeze-proofing of ores and aggregates, thawing agent, concrete conditioner.

MANUFACTURER/IMPORTER:

General Chemical Canada Ltd
201 City Centre Drive
Mississauga, Ontario L5B 3A3

SUPPLIER/DISTRIBUTOR:

General Chemical Canada Ltd.
201 City Centre Drive
Mississauga, Ontario L5B 3A3

EMERGENCY TELEPHONE NO: (519) 736-2111

B. PREPARATION INFORMATION

PREPARED BY: General Chemical Canada Ltd.
Industrial Hygiene Department
Telephone: (519) 736-2111

DATE PREPARED: May 1988

DATE REVISED: March 1991

C. TOXICOLOGICAL PROPERTIES

INHALATION:
Mist inhalation may irritate nose, throat and lungs. May cause nose bleeds.

INGESTION:
Low in toxicity. May irritate gastrointestinal tract and cause nausea and vomiting.

SKIN:
May cause skin irritation. Under conditions of prolonged contact, superficial burns may result. Contact with abraded or broken skin can cause severe necrosis.

EYES:
May irritate or burn eyes.

ACUTE TOXICITY:
Moderately toxic LD_{50} (orl-rat) 1000 mg/kg
Annydrous basis.

CHRONIC TOXICITY:
Not applicable

EXPOSURE LIMITS:
American Conference of Governmental Industrial Hygienists (ACGIH) Threshold limit value - Time Weighted Average (TLV-TWA) guideline for nuisance particulate (liquified mist) 10 mg/m^3

OTHER:

BIOLOGICAL EXPOSURE INDICES (BEI.):
Not applicable

D. PHYSICAL DATA

MATERIAL IS AT NORMAL CONDITIONS:	APPEARANCE AND COLOR:	ODOR THRESHOLD:
LIQUID [x] SOLID [ ] GAS [ ] [ ] _____	Clear to slightly turbid liquid	Odorless
BOILING POINT: 116 °C **FREEZING POINT:** -7 °C (MELTING POINT)	**SPECIFIC GRAVITY:** g/cc (H_2O = 1) 20% $CaCl_2$ 1.19 @ 27°C 34% $CaCl_2$ 1.34 45% $CaCl_2$ 1.47	**VAPOR DENSITY:** (AIR = 1) Not applicable
SOLUBILITY IN WATER: Complete	**pH** Neutral to slightly Alkaline	**VAPOR PRESSURE:** (mm Hg @ 20°C) 1.1 kPa 35% (PSIG) 35% $CaCl_2$
EVAPORATION RATE: (Ether = 1.0) Not applicable Slow <0.3 Fast >3.0 Medium 0.3 - 3.0	**% VOLATILES BY VOLUME:** (AT 20°C) Not applicable	MOLECULAR WEIGHT: 110.99 as anhydrous $CaCl_2$ **COEFFICIENT OF WATER/OIL DISTRIBUTION:** Not Available

E. REACTIVITY DATA

STABILITY:	CONDITIONS TO AVOID:
UNSTABLE [ ] STABLE [x]	Not applicable

INCOMPATIBILITY (MATERIALS TO AVOID):
Reacts violently with bromine trifluoride (BrF_3), or a mixture of boron trioxide and calcium oxide (B_2O_3 + CaO). Water-reactive materials, such as sodium: causes an exothermic reaction. Methyl vinyl ether: starts runaway polymerization reaction. Zinc as in galvanized iron: yields hydrogen gas, which may explode under these conditions.

HAZARDOUS DECOMPOSITION PRODUCTS:
Fumes of Chlorides (Cl^-) are given off at temperatures above 1600°C.

HAZARDOUS POLYMERIZATION:	OTHER PRECAUTIONS:
WILL NOT OCCUR [x] MAY OCCUR [ ]	Will undergo violent polymerization with methyl vinyl ether. The anhydrous, monohydrate, dihydrate and tetrahydrate forms of calcium chloride, when dissolved in water, produce considerable amounts of heat.

F. FIRE OR EXPLOSION HAZARD

CONDITIONS OF FLAMMABILITY:	FLASH POINT: °C
Not applicable	METHOD Not applicable
HAZARDOUS COMBUSTION PRODUCTS: None	

% BY VOL. IN AIR	EXPLOSION HAZARDS:
UPPER FLAMMABLE LIMIT: Not applicable LOWER FLAMMABLE LIMIT: AUTO IGNITION TEMPERATURE: °C	See Section E, Incompatibility

SENSITIVITY TO MECHANICAL IMPACT:
Not applicable

SENSITIVITY TO STATIC DISCHARGE:
Not applicable

FIRE EXTINGUISHING PROCEDURES:
Use extinguishing media appropriate for surrounding fire. For fire fighting wear NIOSH-approved self-contained breathing apparatus

G. HAZARDOUS INGREDIENTS (MIXTURES ONLY)

MATERIAL OR COMPONENT/C.A.S. #	CONCENTRATION	HAZARD DATA
Not applicable		

H. PREVENTIVE MEASURES

PERSONAL PROTECTIVE EQUIPMENT:

RESPIRATORY PROTECTION:

For misty conditions, wear NIOSH-approved mist respirator.
Respirator should not contain any metals corrodible by these solutions.

EYES AND FACE:

For misty conditions, or when handling solutions where there is reasonable probability of eye contact, wear chemical safety goggles and hard hat. Under these conditions, do not wear contact lenses.

HANDS, ARMS, AND BODY:

As a minimum, wear long-sleeve shirt and trousers, impervious boots, gloves and apron, for routine product use.

STORAGE:

Keep container closed. Protect from physical damage. Do not store in metals which this solution corrodes. See Section E.

NORMAL HANDLING:

Avoid contact with eyes, skin or clothing. Avoid breathing mist. Use good personal hygiene and housekeeping.

ENGINEERING CONTROLS:

Ventilation: Provide general and/or local exhaust ventilation to maintain mist or vapour levels below exposure limits.
Eye wash facility should be provided in storage and general work area.

ENVIRONMENTAL:

DEGRADABILITY:

Not applicable

AQUATIC TOXICITY:

Harmful to aquatic life at concentrations greater than 500 ppm. $CaCl_2$ does not bioaccumulate. TL_m 96>1000 mg/1.

SPILL OR LEAK (ALWAYS WEAR PERSONAL PROTECTIVE EQUIPMENT):

Dilute small spills cautiously with plenty of water. Mop into metal drum and cover. (Many metals are slowly corroded by these solutions.) Cautiously spray residue with plenty of water. **Large spills:** dike up with any available absorbent (commercial, sand, etc.). Pump into same containers, and treat as above.

WASTE DISPOSAL:

Consistent with the requirements of local waste disposal authorities.

TDGA CLASS:	PIN:	LABEL:
Not applicable		

I. FIRST AID MEASURES

INHALATION:

Promptly remove to fresh air. Get medical attention if any discomfort from inhalation.

INGESTION:

If conscious, immediately give 2 to 4 glasses of water, and induce vomiting by touching finger to back of throat. Get medical attention promptly

SKIN:

Remove contaminated clothing. Wash with plenty of soap and running water.

EYES:

Flush eyes promptly with plenty of running water, continuing for at least 15 minutes. Get medical attention.

J.

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General Chemical

Product Safety Data Sheet

FLAKE CALCIUM CHLORIDE

A. PRODUCT INFORMATION

TRADE NAME (PRODUCT IDENTIFIER):
FLAKE CALCIUM CHLORIDE
POWDERED CALCIUM CHLORIDE

CHEMICAL NAME AND/OR SYNONYM:
Calcium Chloride, Dihydrate

FORMULA:
$CaCl_2 . 2 H_2O$

CAS NO:
10035-04-8

PRODUCT USE:
Deicer, dust control, mud drilling lubricant, freeze-proofing of ores and aggregates, thawing agent, concrete conditioner.

MANUFACTURER/IMPORTER:

General Chemical Canada Ltd
201 City Centre Drive
Mississauga, Ontario L5B 3A3

SUPPLIER/DISTRIBUTOR:

General Chemical Canada Ltd.
201 City Centre Drive
Mississauga, Ontario L5B 3A3

EMERGENCY TELEPHONE NO: (519) 736-2111

B. PREPARATION INFORMATION

PREPARED BY: General Chemical Canada Ltd.
Industrial Hygiene Department
Telephone: (519) 736-2111

DATE PREPARED: May 1988

DATE REVISED: March 1991

C. TOXICOLOGICAL PROPERTIES

INHALATION:
Dust or mist inhalation may irritate nose, throat and lungs.

INGESTION:
Low in toxicity. May irritate gastrointestinal tract and cause nausea and vomiting.

SKIN:
May cause skin irritation. Prolonged contact when moisture is present may result in superficial burns. Contact with abraded skin or cuts can cause severe necrosis.

EYES:
May irritate or burn eyes.

ACUTE TOXICITY:
Moderately toxic LD_{50} (orl-rat). 1000 mg/kg

EXPOSURE LIMITS:
Ontario Ministry of Labour Time-Weighted Average Exposure Value (TWAEV) for Nuisance Particulate 10 mg/m^3.

CHRONIC TOXICITY:
Not applicable

OTHER:

BIOLOGICAL EXPOSURE INDICES (BEI.):
Not applicable

D. PHYSICAL DATA

MATERIAL IS AT NORMAL CONDITIONS:	APPEARANCE AND COLOR:	ODOR THRESHOLD:
LIQUID [ ] SOLID [X] GAS [ ] [ ] _____	Small White Flakes Very hygroscopic	Odorless
BOILING POINT: Not Available (Dehydration) **FREEZING POINT:** (MELTING POINT) 176 °C	**SPECIFIC GRAVITY:** g/cc (H_2O = 1) Not available	**VAPOR DENSITY:** (AIR = 1) Not applicable
SOLUBILITY IN WATER: 97.7 g/100 ml @ 0°C 326 g/100 ml @ 60°C	**pH** Neutral to slightly Alkaline	**VAPOR PRESSURE:** (mm Hg @ 20°C) Not applicable (PSIG)
EVAPORATION RATE: (Ether = 1.0) Not applicable Slow <0.3 Fast >3.0 Medium 0.3 - 3.0	**% VOLATILES BY VOLUME:** (AT 20°C) Not applicable	**MOLECULAR WEIGHT:** 147.02 **COEFFICIENT OF WATER/OIL DISTRIBUTION:** Not Available

E. REACTIVITY DATA

STABILITY:	CONDITIONS TO AVOID:
UNSTABLE [ ] STABLE [X]	Not applicable

INCOMPATIBILITY (MATERIALS TO AVOID):
Reacts violently with bromine trifluoride (BrF_3), or a mixture of boron trioxide and calcium oxide (B_2O_3 + CaO). Sulfuric acid: yields hydrogen chloride gas, which is corrosive, irritating, and reactive. Water-reactive materials, such as sodium: causes an exothermic reaction. Methyl vinyl ether: starts runaway polymerization reaction. Zinc as in galvanized iron: yields hydrogen gas with solutions, which may explode under these conditions

HAZARDOUS DECOMPOSITION PRODUCTS:
Fumes of Chlorides (Cl^-) are given off at temperatures above 1600°C.

HAZARDOUS POLYMERIZATION:	OTHER PRECAUTIONS:
WILL NOT OCCUR [X] MAY OCCUR [ ]	Will undergo violent polymerization with methyl vinyl ether. The anhydrous, monohydrate, dihydrate and tetrahydrate forms of calcium chloride, when dissolved in water, produce considerable amounts of heat.

F. FIRE OR EXPLOSION HAZARD

CONDITIONS OF FLAMMABILITY:	FLASH POINT: °C
Not applicable	METHOD Not applicable
HAZARDOUS COMBUSTION PRODUCTS: None	

% BY VOL IN AIR	EXPLOSION HAZARDS:
UPPER FLAMMABLE LIMIT: LOWER FLAMMABLE LIMIT: Not applicable AUTO IGNITION TEMPERATURE: °C	See Section E Incompatibility

SENSITIVITY TO MECHANICAL IMPACT:
Not applicable

SENSITIVITY TO STATIC DISCHARGE:
Not applicable

FIRE EXTINGUISHING PROCEDURES:
Use extinguishing media appropriate for surrounding fire. For fire fighting wear NIOSH approved self contained breathing apparatus

G. HAZARDOUS INGREDIENTS (MIXTURES ONLY)

MATERIAL OR COMPONENT/C.A.S. #	CONCENTRATION	HAZARD DATA
Not applicable		

H. PREVENTIVE MEASURES

PERSONAL PROTECTIVE EQUIPMENT:

RESPIRATORY PROTECTION:

For dusty or misty conditions, wear NIOSH-approved dust or mist respirator.

EYES AND FACE:

For dusty or misty conditions, or when handling solutions where there is reasonable probability of eye contact, wear chemical safety goggles and hard hat. Under these conditions do not wear contact lenses.

HANDS, ARMS, AND BODY:

As a minimum, wear long-sleeve shirt, trousers, rubber boots and gloves for routine product use. Cotton gloves permitted for dry product, impervious gloves when using solutions.

STORAGE:

Cool, dry area. Prolonged storage may cause product to cake and become wet from atmospheric moisture.

NORMAL HANDLING:

Avoid contact with eyes, skin or clothing. Avoid breathing dust. Use good personal hygiene and housekeeping.

ENGINEERING CONTROLS:

Ventilation: Provide general and/or local exhaust ventilation to maintain dust or fume levels below exposure limits.
Eye wash facility should be provided in storage and general work area.

ENVIRONMENTAL:

DEGRADABILITY:

Not applicable

AQUATIC TOXICITY:

Harmful to aquatic life at concentrations greater than 500 ppm. $CaCl_2$ does not bioaccumulate. TL_m 96>1000 mg/1.

SPILL OR LEAK (ALWAYS WEAR PERSONAL PROTECTIVE EQUIPMENT):

Shovel up dry chemical and place in metal drum with cover. Cautiously spray residue with plenty of water. Keep contaminated water from entering sewers and water courses.

WASTE DISPOSAL:

Consistent with the requirements of local waste disposal authorities.

TDGA CLASS:	PIN:	LABEL:
Not applicable	Not applicable	Not applicable

I. FIRST AID MEASURES

INHALATION:

Promptly remove to fresh air.

INGESTION:

If conscious, immediately give 2 to 4 glasses of water, and induce vomiting by touching finger to back of throat. Get medical attention for irritation, ingestion, or discomfort from inhalation

SKIN:

Remove contaminated clothing. Wash with plenty of soap and running water

EYES:

Flush eyes promptly with plenty of running water, continuing at least 15 minutes. Get medical attention.

J.

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APPENDIX E.2

Oil Field Brine

REVIEW PARAMETER LIST FOR OIL FIELD BRINE

A. GENERAL INFORMATION

Oil field brine, also referred to as formation water, is a clear to slightly turbid water without odour, that is with drawn from wells during oil drilling operations. It usually contains salts in solution (calcium, magnesium, and sodium chloride, at average concentrations of 12, 4 and 9 percent respectively) as well as other dissolved minerals associated with the region of extraction. It is usually applied for dust suppression in south western Ontario, as it is generated by the petroleum industry in that region. Other uses for oil field brine are as tire ballast, winter ice control, and well killing (to prevent gas from exiting).

SUPPLIER/DISTRIBUTOR INFORMATION

Manufacturer

Oil field brine is not generated in the Province of Ontario for the purpose of road dust suppression. It is a liquid associated with the production of crude oil and natural gas. The liquid must be disposed of by either pumping it back into the ground with Ministry of Natural Resources approval, or by removal from the well sites by contractors/applicators.

Supplier Information

Several companies involved in oil drilling operations supply the oil field brine to the applicators. The Ontario Petroleum Institute can be contacted for information on potential suppliers of oil field brine.

Applicators/Contractors

There are two major contractors in Ontario who store and apply oil field brine for dust suppression. These are:

Harold Marcus Ltd.
R.R. #3
Bothwell, Ontario
N0P 1C0

Telephone: (519) 695-3734
Contact: Dennis Marcus

McKeegan Trucking Ltd.
R.R. #1
Sombra, Ontario
N0P 2H0

Telephone: (519) 864-1782
Contact: Bruce McKeegan

COST INFORMATION

The oil field brine is usually given away by the oil drilling operations to the contractors free of charge, if the contractors agree to remove the brine all year round. The companies who own the wells would otherwise have to pay for disposal of the brine.

Application costs range from $0.02 to $0.04/L (1991) applied to municipal roads, depending on distance from the contractors site. Based on 2 to 4 applications per season, this results in a seasonal cost of approximately $0.09 to $0.4 per square meter (typical $0.14/$m^2$). More frequent applications may be required at industrial sites and would be more expensive to cover trucking and labour expenses.

SAFETY PROCEDURES

Personal Protection

The following steps from the oil field brine Material Safety Data Sheet (Harold Marcus Ltd.) help to ensure the protection of applicators:

1. Applicators should avoid all eye and skin contact with oil field brine.

2. Applicators should wear long sleeve shirts, trousers, impervious boots, gloves and apron if there is a chance of contact with oil field brine.

3. Applicators should wear NIOSH[1]-approved mist respirators for misty conditions. The masks should not contain metals corrodible by oil field brine.

4. Applicators should wear chemical safety goggles when handling oil field brine with a reasonable chance of eye contact (such as when manually filling tanks).

---

1 National Institute for Occupational Safety and Health

Emergency First Aid

First aid procedures are outlined in the attached Material Safety Data Sheet for oil field brine.

Storage Requirements

Oil field brine should not be stored in metal containers which the solution corrodes (such as galvanized iron containing zinc). Containers should be kept closed and protected from physical damage.

Transportation and Shipping Requirements

Oil field brine is transported via tanker truck. No special handling requirements are necessary.

Spill Procedures

In accordance with Part 9, Section 79 of the Environment Protection Act, a spill is defined as any discharge, intentional or unintentional, of material from its containing unit beyond the recommended maximum application rate, into the natural environment. This can be caused by spray bars left on after operation, tank rupture, tank turn over, etc. In the event of a spill the following procedures are recommended:

1. The spill should be isolated and contained as best possible.

2. All Provincial and Federal Agencies as required by law are to be notified immediately including:

    - The Ontario Ministry of the Environment Spills Action Centre at (800) 268-6060.

    - The municipality in which the spill occurred.

    - Environment Canada at The Ontario Regional Environmental Emergencies line: (416) 973-1059, or (416) 346-1971 (cellular).

SOURCE DESCRIPTION AND QUALITY CONTROL

Oil field brine is brought to the surface during the production of crude oil and natural gas. It is primarily composed of formation water with minor quantities of soluble chemicals.

Both major contractors test the stored salt brine once per year for calcium chloride, magnesium chloride, and sodium chloride concentrations. Specific gravity is also measured in every load to be used on roads.

B. TECHNICAL EFFECTIVENESS AND APPLICATION PROCEDURES

TECHNICAL EFFECTIVENESS

Oil field brine performs as a dust suppressant and road stabilizer in much the same manner as calcium chloride, although not as effectively, because of its lower calcium chloride concentration. Oil field brine's technical effectiveness varies with the traffic volume, weight, rate of application climatic conditions, and soil composition.

To evaluate the technical effectiveness of oil field brine, a telephone survey of applicators and current users of oil field brine in Ontario, as well as a general literature search were conducted.

In general, users surveyed for this study indicated that oil field brine performs acceptably when applied on roads with light volume traffic, but effectiveness degrades on more frequently travelled roads. Vehicles heavier in weight, such as trucks, also tend to reduce the effective lifetime of the oil field brine. A Canada wide survey of Canadian road agencies conducted by the Roads and Transportation Association of Canada (UMA Engineering Ltd., 1987) confirmed the Ontario findings, that is; oil field brine is most effective on roads with low volume and lighter weight traffic, such as cars.

The only other province that reported using oil field brine as a dust suppressant was Alberta. Oil field brine used in southern and central Alberta is reported to be comparable in performance to calcium chloride (UMA Engineering Ltd., 1987).

Municipal road agencies indicated that application frequencies are once every two months during the dust suppression season. Less frequently travelled roads, with light weight vehicles, such as park roads, require less frequent applications. At one Ontario industrial site, oil field brine is applied every two weeks because the heavy truck traffic quickly deteriorated the road surface and the dust suppressing effectiveness of the oil field brine.

A report on dust suppressant use for controlling dust emitted from unpaved roads in the iron and steel industry compared oil well brine against calcium lignosulphate and an emulsified asphalt resin (Russell, 1983). The oil field brine was applied five times over a period of 14 days before testing began, for a total of 20.5 L/m^2 applied. At this application rate, complete control of fines was demonstrated. Russell recommended that oil field brine be reapplied when the salt concentration drops to half of the concentration represented by the rate at which complete control is achieved. It should be pointed out that the application of 20.5 L/m^2 used in Russel's study is about seven times the normal municipal applications rate.

The unusually high application rates of 20.5 L/m^2 in the Russell study provided uncharacteristically high dust suppression efficiencies; oil field brine was as efficient as emulsified oil resins. In a field study for the Ontario Ministry of the Environment, several dust suppressants were applied to municipal roads in Southern Ontario (Acres, 1988). Stationary measurements of dust emitted from treated road surfaces were taken over a three month period. The results showed that oil field brine was one of the poorest performers. The moving vehicle dust measurement results are more accurate because of superior measuring techniques and the absence of wind direction as a variable. These results indicated that oil field brine was the least effective dust suppressant with dust levels measured from the surface 2,000 times those of calcium chloride.

Municipal users surveyed in this study confirmed that oil field brine has lower dust suppressing efficiencies than other dust suppressants, particularly after periods of significant rainfall. Since the salts in oil field brine are water soluble they have a tendency to leach out after periods of significant rainfall. Thus, rain reduces the effective lifetime of the oil field brine, and results in deterioration of the road surface. The results in the iron works study (Russell, 1983) also show that the effectiveness of the oil field brine is reduced over time, especially after periods of rain.

Another climatic condition that reduces the technical effectiveness of the oil field brine is very dry weather. Since calcium chloride, the main component oil field brine, is deliquescent, it requires moisture to bind the road materials. Calcium chloride performs best in regions with over 50 percent relative humidity (Public Works Canada, 1983).

Because oil field brine is essentially a dilute solution of calcium chloride, the effects of surface composition on dust suppressant performance is believed to be similar for both dust suppressants. Oil field brine, is therefore, not effective in sandy soil, soil with no fines, or soil with fines in excess of 8 to 10 percent. Under those circumstances the effectiveness of calcium chloride is reduced because these soil types reduce the dust suppressant's ability to bind the surface (See Review Parameters List for Calcium Chloride).

Summary of Overall Effectiveness

The performance of oil field brine is dependent on several factors, including:

1. Oil field brine generally performs best on roads with lower traffic volumes and light weight vehicles such as cars. High volumes or heavy vehicles such as trucks tend to quickly reduce the effective lifetime of oil field brine.

2. Application frequencies of oil field brine vary with the site. Industrial locations report applications as frequently as every two weeks or less, while municipal road services report application frequencies every two months.

3. Unusually high application quantities of oil field brine can produce dust control efficiencies for treated roads equal to those for roads treated with emulsified oil resins. Under these circumstances, reapplication is recommended when salt concentrations in the soil fall to 1/2 of the value that controls fines at a 100 percent level. However, these recommended application rates are 3 to 7 times the usual municipal rate.

4. Under typical municipal dust suppressant application rates (3 L/m^2), oil field brine has been shown in one study to be one of the least effective dust suppressants used in Ontario.

5. Heavy rain has a tendency to leach the salts in oil field brine from the road surface, thereby reducing the technical effectiveness, and shortening the lifetime of effective dust control.

6. A relative humidity of about 50 percent or more is recommended for oil field brine use. Thus, very dry weather has a negative impact on the effectiveness of oil field brine.

7. Soils with high sand or high fines content, or no fines content, are not recommended for treatment with oil field brine, since binding of the surface for dust suppression cannot be achieved.

APPLICATION PROCEDURES

Site Restrictions

According to the Ontario Ministry of Environment's Draft Guidelines for the Application of Dust Suppressants, product dust suppressants should not be applied to sites closely adjacent to or crossing waterway(s) or marshes, or near wells.

Surface Preparation

Published literature prescribing the road preparation procedures for the application of oil field brine was not identified in the literature search. Preparation information was obtained from the telephone survey of municipalities and contractors conducted for this study.

According to the telephone survey, surface preparation is usually no more than grading to remove potholes and corrugations. However, the suggested preparation for oil field brine application, is as follows:

1. Proper drainage should be provided for the yard or on both sides of the road.

2. The surface should be graded to a significant depth (20 to 50 mm) to remove pot holes, corrugations and other ruts. If the road is deeply rutted or corrugated it may require scarification between 25 and 100 mm.

3. Gravel or fines should be added as required to yield a final composition of 10 to 15 percent fines (<200 mesh) (UMA Engineering Ltd., 1987).

4. The road must be shaped to the correct crown (about 4% straight line) using a grader equipped with a straight flat blade.

5. Oil field brine should be applied while the surface is still moist.

6. Compaction of the surface is suggested to provide a firm solid base, particulary if the surface is being constructed.

Length of Time Before and After Precipitation

Application of oil field brine is generally made while the road surface is moist/damp. Usually, this is about 6 to 12 hours after a significant rainfall, depending on the time of year. Application should be made 12 to 24 hours before the next rainfall, depending on humidity, to permit curing and hardening of the surface. If heavy rains are expected, the brine should not be applied until afterwards to prevent leaching and runoff.

Application Equipment

Application equipment for calcium chloride can also be employed for the use of oil field brine. Literature on equipment specifically for oil field brine application was not identified. The application equipment for calcium chloride application outlined by the various provincial transportation agencies vary significantly. Although not

adopted in Ontario, the British Columbia guidelines are presented here, because they are the most comprehensive guidelines that were identified for application equipment. These are presented below (UMA Engineering Ltd., 1987):

- A pressurized distributor tanker truck of no less than 18,000 litres capacity, unless limited by narrow or steep roads.
- A quick opening gate in the dome.
- A dipstick calibrated in 10 mm increments with calibration chart.
- An external readily visible depth gauge with 50 litre accuracy.
- Rear mounted spray bars and nozzles 0.6 to 3.6 m wide capable of:
  - vertical and lateral adjustment
  - producing double coverage in one pass.
- Spray bars that do not extend into the lane of opposing traffic unless adequate warning measures are taken.
- The feed to the spray bars equipped with:
  - recirculation before and during operation
  - filters.
- Spray nozzles:
  - fitted with instant on/off valves, and,
  - which yield fan-shaped sprays without atomization.
- A pressure pump capable of applying a minimum of 120 litres of material per minute per meter spray bar.
- An operator visible 15 kPa pressure gauge.
- An operator visible flow meter.
- An operator visible fifth wheel tachometer calibrated in meters per minute.

Personnel Requirements

Typically, two to four people are required for safe application. This would consist of at least one, maybe two, flag persons and or operator of a pilot warning vehicle, the operator of the application truck, and a checker (the flag person can double as the checker).

Dilution

Oil field brine is not usually diluted as effectiveness is reduced. It could be diluted with water, but should not be mixed with any other liquid without Ministry of the Environment review.

Application Rate and Frequency

In municipalities across Ontario, oil field brine is applied twice per season, and often up to 3 to 4 times. Drier seasons may warrant even more applications of product. Industrial applications rates vary from 3 to 18 L/m^2, which may have an effective period as short as 2 weeks under certain industrial use conditions. Municipalities apply from 1.5 to 3.2 L/m^2 throughout South Western Ontario depending on the need, climatic conditions, and surface conditions/compositions. Application rates do not vary for subsequent applications.

Ponding should be avoided during application. Ponding will depend on several factors: the rate of oil field brine discharge, the speed of the application truck, and the porosity of the surface materials. Ponding can be prevented by shutting off the spray bars when the vehicle/truck is stopped or is passing over paved/sealed portions of the road. Care should also be taken to ensure that the liquid is applied at or below the suggested rates. If ponding still occurs, then a decrease in the application rate is necessary.

Curing Time

Traffic may be allowed on the road immediately after application. Curing time (12 to 24 hours) depends on relative humidity and ambient temperature after application.

Problems/Hazards

Roads treated with oil field brine may be slippery after periods of rain.

C. PHYSICAL AND CHEMICAL CHARACTERISTICS

PHYSICAL PROPERTIES

The physical characteristics of oil field brine are presented in Table 1.

Table 1 Physical Properties of Oil Field Brine	
Property	**Oil Field Brine**
Odour	Odourless
Appearance and colour before application	Slightly turbid
Physical state when applied	Liquid
Physical state when dry	Solid
pH	Neutral to slightly alkaline
Solubility in water	Complete
Vapour pressure relative to water	Less than water
Freezing point	-7 °C
Boiling point	Higher than water
Specific Gravity	1.2
Source: Oil field brine Material Safety Data Sheet (Den-Mar Brines Ltd., 1983).	

CHEMICAL PROPERTIES

Oil field brine is about a 30 percent solution of calcium, sodium and magnesium chloride in water. Table 2 presents composition data provided by the two Ontario oil field brine contractors.

Table 2 Data on the Composition of Oil Field Brine			
Constituent	**Units**	**McKeegan[1]**	**Marcus[2]**
Chloride	mg/L	210,000	162,000
Calcium	mg/L	34,000	43,000
Sodium	mg/L	38,000	35,000
Magnesium	mg/L	NA	10,000

Notes

1. Analytical data from McKeegan Trucking Ltd (1990)
2. Information provided by Harold Marcus Ltd (1991)

NA Not analyzed

One sample of oil field brine was provided by McKeegan Trucking Ltd. for this study. This sample was from an oil field brine storage pond, which contains brine from several sources. The sample was split at the laboratory for duplicate analyses of chemical components. All analyses were carried out by CANVIRO Analytical Laboratories Ltd. Average results for the duplicate analyses are presented in Table 3.

Table 3
Chemical Characteristics of Oil Field Brine

	Units	Study[1] Sample Concentration
Conventional Parameters		
pH		5.8
Total solids	mg/L	312,000
BOD_5	mg/L	<300
Ammonium Nitrogen	mg/L	174
Total Phosphorus	mg/L	0.24
Oil & Grease	mg/L	<1.0
Chloride	mg/L	157,000
Sulphate	mg/L	<148
Metals		
Aluminum	mg/L	0.52
Boron	mg/L	6.49
Barium	mg/L	0.23
Beryllium	mg/L	0.008
Cadmium	mg/L	<0.012
Calcium	mg/L	38,000
Chromium	mg/L	<0.02
Cobalt	mg/L	<0.03
Copper	mg/L	0.035
Iron	mg/L	6.16
Lead	mg/L	<0.10
Magnesium	mg/L	2,845
Manganese	mg/L	0.59
Vanadium	mg/L	0.41
Zinc	mg/L	0.3
Nickel	mg/L	<0.02
Silver	mg/L	<0.02
Strontium	mg/L	690
Sodium	mg/L	6,670
Arsenic	mg/L	<0.05
Selenium	mg/L	<0.01
Mercury	mg/L	<0.001

Notes:

1. Average of results for duplicate analyses of oil field brine sample provided by McKeegan for this study.
< Below detection limit.

Table 3 shows a solids content of 312,000 mg/L which is equal to a concentration of about 23 percent by weight given a density of about 1.2 kg/L. A few metals were detected in the sample, at concentrations less than 1 mg/L with the exception of strontium and boron. Ammonia levels were 174 mg/L.

D. TOXICITY AND SUB-LETHAL EFFECTS

ACUTE TOXICITY

B.A.R. Environmental carried out acute toxicity testing on the same sample of oil field brine provided for chemical analysis. LC50 values and their 95 percent confidence intervals were measured in test species of rainbow trout and Daphnia magna in duplicate samples. The LC50 is the median lethal concentration (i.e. the concentration of the test chemical in water that is estimated to be lethal to 50 percent of the test organism within a prescribed period of time).

Acute toxicity of oil field brine is presented in Table 4. According to one rating system (IMCO/FAO/UNESCO/WMO, 1969), oil field brine toxicity rates a grade 0 on a scale of 0 to 4, meaning it is "practically non-toxic".

Table 4
Acute Toxicity of Oil Field Brine to Rainbow Trout and Daphnia Magna

Organism	Length of Test Period	Effect	Lethal Concentration (mg/L)	95% Confidence Interval (mg/L)
Rainbow Trout	96	LC50	52,305	44,099-62,037
Daphnia Magna	48	LC50	24,000	18,000-32,000

Other Acute Toxicity Information

Anhydrous calcium chloride is moderately toxic to mammals, with an oral rate toxicity of 1,000 mg/kg (Calcium Chloride MSDS). The MSDS indicates that the chemical compound calcium chloride in solution at a concentration of 500 mg/L is harmful to aquatic life. Based on a calcium chloride solution strength of 8.8 percent present in the study sample, lethal calcium chloride concentrations were 4,600 mg/L[2] for rainbow trout and 2,105 mg/[2] for Daphnia magna, compared to harmful concentrations of 500 mg/L.

In a study on the environmental impacts of calcium chloride, it was reported that chloride levels exceeding 4,000 mg/L were harmful to pike, bass and perch (School of Public Health, 1982). Chloride levels in oil field brine analyzed for this study were 6,843[3] mg/L at the lethal concentration to rainbow trout.

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2 Rainbow trout 8.8% (52,305 mg/L) = 4,600 mg/L, Daphnia magna 8.8% (24,000 mg/L) = 2,105 mg/L

3 Rainbow trout 157,000 mgCl⁻/L x 52,305 mg/L / 1,200 g/L = 6,843 mgCl⁻/L

SUB-LETHAL EFFECTS

Limited information is available on the sub-lethal effects oil field brine. Therefore, this information was supplemented with available information on the sub-lethal effects of those contaminants found in the sample above guidelines and objective concentrations for drinking water and aquatic life, as presented in Table 5.

Table 5
Comparison of Contaminant Limits for Drinking Water and Aquatic Life to Concentrations in Oil Field Brine[1]

Parameter	Aquatic Life	Drinking Water	Oil Field Brine
Chloride (mg/L)	n/a	250[2]	157,000
Aluminum (µg/L)	5-100[2,4]	200[5]	520
Iron (µg/L)	300[2]	300[2,4]	6,160
Manganese (µg/L)	n/a	100[5], 50[2], 500[3]	590
Boron (µg/L)	n/a	5,000[2,3]	6,490
Sodium (mg/L)	n/a	200[5,3]	6,670
Calcium (mg/L)	n/a	No need to set numerical guidelines[6]	38,000
Magnesium (mg/L)	n/a	No need to set numerical guidelines[6]	2,845

Notes:

1. Only parameters with concentrations exceeding referenced limits are presented.
2. Ontario Ministry of the Environment, 1984. Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.
3. Health and Welfare Canada, 1987. Canadian Guidelines for Drinking Water Quality.
4. Environment Canada & Health and Welfare Canada, 1991. How safe is our water.
5. World Health Organization, 1984. Guidelines for Drinking Water Quality, Volume 2 Health Criteria and other supporting information.
6. Health and Welfare Canada. 1991, Personal Communication.

Comparing the concentrations of toxic substances in 100 percent strength of the dust suppressant product provides an indication of toxicity to human and aquatic life only on a "worst case" basis. Some dilution effects will occur once the material is released to land and exposed to the effects of runoff, leaching and degradation. In addition, concentration of persistent substances after repeated application may also occur. The exact extent of dilution or build-up will depend largely on site specific factors and will not be addressed in generic assessments of sub-lethal effects.

In the absence of a detailed exposure and risk assessment, it is not possible to completely assess the degree of human or environmental health risk posed by the use of oil field brine. The following discussion attempts only to identify the contaminants

of concern which could potentially cause problems over the long term. In many cases, the toxological data available is limited.

Main Components

The single dose oral toxicity of salt brine is low. The oral LD50 of a sodium salt brine for rats is 3,550 mg/kg (DOW MSDS). However, excessive exposure may cause nausea, vomiting and diarrhoea (Brine MSDS, 1990). A single prolonged exposure to oil field brine is not likely to result in the material being absorbed through skin in harmful amounts. The LD50 of a sodium salt brine mixture for skin absorption in rabbits is >10,000 mg/kg (Brine MSDS, 1990). Inhalation, intratracheal instillation and intravenous injection of brine solution induce tumours in experimental animals (Brine MSDS, 1990). It may cause moderate eye irritation and slight corneal damage.

Contaminant Based Assessment

The major cationic components of oil field brine were found in small quantities except calcium, magnesium, sodium and chloride. The main environmentally significant characteristic of calcium, magnesium, and sodium chlorides are their extremely high water solubility giving rise to highly mobile ions of calcium, magnesium, and sodium. High ionic strength waters resulting from runoff have the potential to cause salt-effect damage to vegetation and increase salinity of receiving waters.

While it has been stated that calcium chloride, a major component of oil field brine, may adversely affect aquatic species, no documentation was found to indicate these effects have occurred from the use of oil field brine as a dust suppressant on roads. In fact, aquatic biota would be much more tolerant to most metal contaminants in the presence of calcium and magnesium.

High level of salts such as sodium in surface water may create salinity problems to fresh water biota.

Calcium is absorbed into vegetation and is generally beneficial to plant life. Chloride is also absorbed in small amounts, but can be toxic at very low concentrations. Chloride toxicity to plants is variable, depending on plant type, resistance, nutrient balance and season. Effects on plants exposed to soil salts include reduction in growth, leave browning, premature fall colouring, twig and branch dieback and in some species, death.

No guidelines exist for soil concentrations of chloride. Roadside grasses were reportedly not affected when soil chloride concentrations were 2,650 to 4,900 mg/kg, as a result of road deicing and dust suppressant applications (Acres, 1988). Trees like sugar and red maple tolerate chloride soil levels up to 2,000 mg/kg, while white

poplar and red oak can tolerate up to 6,000 mg/kg. Grasses tend to be much more tolerant of chloride than trees (Salt Institute, 1971).

A number of metals exceeded the relevant guidelines slightly. However, only a few of these might be of human or environmental concern. Aluminum, iron and boron are not likely to cause toxic or sub-lethal effects unless injested in massive amounts. Ill effects to sodium sensitive individuals due to high levels of sodium in drinking water have been documented. Aluminum and boron may accumulate in aquatic animals and biota. Again, this would only occur with exposure to excessive amounts. Toxic effects of metals in the environment resulting from dust suppressant application would not likely be a concern if care is taken not to apply the material in the vicinity of waterways.

SUMMARY

The following main points summarize the acute toxicity and sub-lethal effects of oil field brine:

- The acute toxicity (LC50) of oil field brine to rainbow trout (96 h) was measured to be 52,305 mg/L. The acute toxicity (LC50) to Daphnia magna was measured to be 24,000 mg/L.

- Anhydrous calcium chloride is moderately toxic to mammals, with an oral LD50 of 1,000 mg/kg for rats.

- Calcium present in oil field brine has no relevant sub-lethal effects and will be beneficial to vegetation. Furthermore, aquatic species are more tolerant to metals in the presence of calcium.

- Chloride present in soils negatively affects vegetation growth and germination, depending on the tolerance of the species and the soil concentration. Chloride produces an undesirable taste at high levels in drinking water (250 mg/L).

- Several metals were present in oil field brine solution at levels slightly above guidelines and objectives for drinking water and aquatic life. Under normal dust suppressant use, these would not pose any environmental or human health concern.

E. ENVIRONMENTAL IMPACTS

MAIN COMPONENTS

Two physical processes are involved in the movement of oil field brine through the biosphere. These include the rate and extent of migration of the hydrated salts, and the factors which govern the concentration of the dissociated ions at any given distance from the application site. The latter is discussed under the following heading.

The active dust suppressing compound in oil field brine is calcium chloride. Calcium chloride applied to unpaved surfaces absorbs moisture from the surface and/or the atmosphere, and penetrates the road surface to bind soil particles. Trapped moisture resists evaporation, and the treated surface remains damp even in hot weather. Calcium chloride does not crystallize and accumulate on road surfaces, and therefore, air dispersion of salt is minimal (School of Public Health, 1982).

Calcium chloride moves through the environment with water, and this movement is dependent on the amount of precipitation, drainage and chemical and physical properties of the soil. Because it is associated with water, it will move deeper into the soil during wet periods, and return back to the road surface during dry periods. Although vertical movement has been shown to occur somewhat, lateral movement occurs at a much lower rate. In one study of calcium chloride application on roads, 23 percent of the original amount of calcium chloride remained at a depth of 38 cm after 55 months on a sandy clay surface, but only 4.1 percent was found in the shoulder 60 cm from the road (Ogden, 1976). In the Acres (1988) study where salt brine was applied, chloride levels in the treated road material were up to 20 times higher than in ditch materials, and were 6 to 20 times higher in the first 10 cm depth than in the 10 to 20 cm range.

With significant rainfall, or where there are high drainage rates (eg. steep slopes, impervious soil, or porous soil), calcium chloride and the other salts in oil field brine move with water as surface runoff or soil leachate. In these conditions, the constituent ions, Ca^{2+}, Mg^{2+}, Na^{+} and Cl^{-} dissociate and migrate through the environment (School of Public Health, 1982).

COMPONENT BASED ASSESSMENT

To evaluate the environmental impacts of oil field brine applications, impacts of each of the major components, as well as those contaminants identified in Table 3, were reviewed. These included:

- Calcium
- Chloride

- Sodium
- Metals
- Ammonia

Calcium

The calcium ion is readily absorbed by soil particles, and the amount of adsorption is dependent on soil type. Properties that affect adsorption include the organic and clay content, soil particle size, exchangeable ions present, bulk density, etc.

The calcium ion readily replaces ions such as sodium and hydrogen on soil particles. Furthermore, in the presence of high calcium concentrations, magnesium, barium, mercury, copper and lead may also be replaced, and released into soil water and surface runoff (School of Public Health, 1982).

Chloride

The monovalent, negatively charged chloride ion (Cl^-) essentially remains in solution and moves readily through the environment with water.

Environmental impacts of chloride as a result of dust suppressant applications have not been studied. However, impacts have been reviewed extensively with respect to road deicing (Salt Institute, 1971; School of Public Health, 1982). These effects of chloride migration could be extrapolated to dust suppression and include (Salt Institute, 1971):

- Trees along deiced road ways are less vigorous than on untreated roadways.

- Surface water collects chloride ions contained in runoff. Studies have shown that chloride levels have increased in surface waters in the vicinity of road deicing to varying levels, depending on dilution effects. Chloride concentrations in major rivers in the State of Maine increased an average of 5 to 9 mg/L from headwaters to river mouths in a two year study period, with the greatest increase occurring where roads were the most dense. The Salt Institute reports that water drainage entering large water systems were not seriously effected by chloride concentrations resulting from deicing. It has been estimated that the chloride concentration in Lake Erie has risen about 2 mg/L form the year 1910 to 1964 because of road deicing.

- Wells have also been reported to be contaminated by road deicing with salts. The pollution of well water is not usually due to groundwater contamination, but from concentrated surface runoff intrusion into the wells.

The amount of chloride applied to roadways for dust suppression is estimated to be one third of the quantity applied for road deicing annually. In a study for the Ontario Ministry of the Environment, chloride levels in vegetation near roadways treated with salt brine were almost 2 times that of normal background concentrations (Acres, 1988).

In surface waters, chloride can react with mercury, released from bottom sediments in the presence of calcium. The soluble form of mercury that results is then available for uptake by aquatic biota (School of Public Health, 1982).

Sodium

Sodium is an undesirable contaminant in water from aquifers and surface water, as well as in soil. Sodium is a problem in the soil solution as a component of total salinity, which at varying levels creates toxicity problems for adsorption. Sodium is also of interest in drinking water, since sodium restricted diets are often recommended to address human health concerns.

Sodium salts have a very high solubility coefficient, meaning they are readily dissolved in rain water, making sodium one of the more mobile components of oil field brine (Acres, 1990). The quantity of sodium applied to road by application of oil field for dust suppression is several order of magnitude lower than the amount released by standard winter road salting practices.

Metals

None of the metals analyzed in the study sample of oil field brine solution were present at levels greater than the guidelines and objectives levels for soils. In a study for the Ontario Ministry of the Environment (Acres, 1988), metals studied in oil field brine were lower than crustal abundance concentrations. Furthermore, levels in treated road surface materials, road ditch materials and site vegetation near the treated site, were not attributed to the effects of salt brine applications. The results indicate that oil field brine did not increase soil metals levels under normal use. However, long term effects of metals build-up in treated soils and surrounding areas have not been measured.

Summary

The following points summarize the environmental impacts of oil field brine used as a dust suppressant:

- Calcium chloride in oil field brine moves through the environment with water, and therefore, it will move deeper into the soil during wet periods, and return back to the surface in dry periods.

- During significant rainfall or where there are high drainage rates, oil field brine will dissociate into constituent ions (Ca^{2+}, Mg^{2+}, Na^{+}, Cl^{-}) and will move with surface runoff or leachate.

- Calcium does not generally migrate extensively, as it becomes adsorbed to soil particles. This adsorption may release more readily exchangeable ions such as mercury, copper and lead.

- Literature on the effects of chloride as a result of dust suppression was not identified. Literature focuses on road deicing, where the amount of chloride applied to roads is approximately 3 times higher than for dust suppression. Environmental impacts of chloride from road deicing include:

  - Increases in river and lake chloride concentrations, reported to be not significant.

  - Increases in chloride levels in well water supplies, as a result of surface contamination rather than aquifer contamination.

  - Creating the potential for release of soluble mercury from bottom sediment in surface waters.

- Sodium present in calcium chloride solution is a very mobile ion that will migrate with runoff and groundwater. The quantity of sodium applied in calcium chloride applications, is several orders of magnitude less than used for road deicing.

- One study has shown that heavy metals applied to roads from oil field brine applications did not significantly increase the background levels of these metals at the application site.

F. OTHER IMPACTS

The use of oil field brine as a dust suppressant has some potentially negative side effects (Brown, 1989; Acres, 1988). Complaints are often made about the following:

- Acceleration of corrosion on vehicles travelling on salted roads.
- Exposed leather will dry and become stiff, cracked, or even brittle.
- Scaling and deterioration of pavement, roads and bridges (Salt Institute, 1971).
- Slipperiness of road surfaces during periods of rain.

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION		
MANUFACTURER'S NAME DEN-MAR BRINES LIMITED	REGULAR TELEPHONE NO 519-695-2805 EMERGENCY TELEPHONE NO	
ADDRESS R.R. #3 BOTHWELL, ONTARIO. NOP 1CO		
TRADE NAME DEN-MAR BRINES LIMITED		
SYNONYMS "LIQUID BALLAST"-DUST CONTROL		

II HAZARDOUS INGREDIENTS		
MATERIAL OR COMPONENT	%	HAZARD DATA
None - This material is about a 30% solution		
of calcium, sodium and magnesium chloride in		
water.		

III PHYSICAL DATA			
BOILING POINT 760 MM HG	Higher than water	MELTING POINT -30°C	
SPECIFIC GRAVITY (H_2O=1)	1.2 +	VAPOR PRESSURE	Less than water
VAPOR DENSITY (AIR=1)	Less than water	SOLUBILITY IN H_2O, % BY WT	Infinitely
% VOLATILES BY VOL	75%	EVAPORATION RATE (BUTYL ACETATE=1)	0.1 or less
APPEARANCE AND ODOR	Clear and odour-free		

IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)	No Flash Point	AUTOIGNITION TEMPERATURE	None
FLAMMABLE LIMITS IN AIR % BY VOL	NON FLAMMABLE		LOWER
EXTINGUISHING MEDIA	Self - Extinguishing		
SPECIAL FIRE FIGHTING PROCEDURES	None		
UNUSUAL FIRE AND EXPLOSION HAZARD	None		

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION: Liquid Inhalation of spray may cause irritation

SKIN CONTACT: May cause slight itch

SKIN ABSORPTION: Nil

EYE CONTACT: Will cause irritation

INGESTION: May cause discomfort, also may be absorbed through digestive tract

EFFECTS OF OVEREXPOSURE: No effects

ACUTE OVEREXPOSURE: None, unless fall occurs into container

CHRONIC OVEREXPOSURE: Nil

EMERGENCY AND FIRST AID PROCEDURES

EYES: Wash out with water

SKIN: Wash out with water

INHALATION: No vapour except water

INGESTION: Drink adequate water for dilution

NOTES TO PHYSICIAN: Water dilution is best in all cases

VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

None

INCOMPATIBILITY

Insoluble in most organic liquids

HAZARDOUS DECOMPOSITION PRODUCTS

None

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

Does not polymerize

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Use any type of absorbent. Also, water can be used for dilution where this is reasonable.

NEUTRALIZING CHEMICALS

None required

WASTE DISPOSAL METHOD

When sufficiently diluted the impact on the environment is nil.

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

None

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL)

Nothing but water vapour is given off unless heavy liquid is splashed or sprayed

EYE

Use goggles - wash with water if eyes get contaminated

GLOVES

Should be used

OTHER CLOTHING AND EQUIPMENT

Rubber boots and aprons for massive general exposure to spills

IX SPECIAL PRECAUTIONS

PRECAUTIONARY STATEMENTS

This is a water solution of calcium chloride, sodium chloride and magnesium chloride with traces of related chloride salts. In effect, it is concentrated sea water.

OTHER HANDLING AND STORAGE REQUIREMENTS

Nothing special. Steel will rust more quickly than it will with water only.

PREPARED BY D. S. ALEXANDER M.Sc., F.C.I.C.

ADDRESS LAMBTON SCIENTIFIC INC., SARNIA, ONTARIO

DATE OCTOBER 24, 1983

APPENDIX E.3

Tembind

REVIEW PARAMETER LIST FOR TEMBIND A-002

A. GENERAL INFORMATION

Tembind A-002 is a 50 percent solids solution of lignin sulphonate and is classified as a lignosulphonic acid-ammonium salt. Tembind A-002 is commonly called an ammonium lignosulphonate. In its liquid form, it is a dark brown solution with a woody odour. In its processed dry form, it is a brown powder with the same odour. Tembind A-002 is manufactured from the lignin content in trees. It is usually diluted with water to a 25 or 35 percent solids solution, called Tembind 25 and Tembind 35. Tembind A-002 is also used as a dispersant and water reducer in concrete, as a pellet binder in animal feed, in animal molasses, and as a replacement for formaldehyde in particle board.

SUPPLIER/DISTRIBUTOR INFORMATION

Manufacturer and Supplier

Temfibre Inc.
P.O. Box 3000
George Petty Road
Temiscaming, Quebec
J0Z 3R0

Telephone: (819) 627-9505
Contact: Jim McCallum

Temfibre Inc. also distributes the product.

Applicators/Contractors Information

Jim McCallum ((819) 627-9505) of Temfibre Inc. or Mr. Larry Ellerker ((416) 235-4046) of the Ontario Ministry of Transportation can be contacted for information on applicators of Tembind.

COST INFORMATION

Product costs for a 50 percent solids solution are about $66 per tonne (1991) from the manufacturer.

The manufacturer either delivers and applies Tembind, or the product is picked up by one of Temfibre's distributors. Costs for delivery or pick-up (1991) range from $500 to $800 per load (43 tonnes) or $10 to $18 per liquid tonne delivered.

Final application costs to users are approximately $95 per liquid tonne of 25 percent solids solution. Sandy soil areas warrant the use of 35 percent solution, which costs about $133 per tonne. The total 1991 costs to users range from $0.1 to $0.2 per square meter per season.

SAFETY PROCEDURES

Personal Protection

Since Tembind A-002 is a non-corrosive or reactive, natural, biodegradable dust suppressant, only minimal protection is required in its handling, such as impervious gloves and safety goggles.

Emergency First Aid

First aid procedures are listed in the attached Material Safety Data Sheet for Tembind A-002.

Storage Requirements

Special containers are not required for storing liquid Tembind A-002. However, the product will stratify (settle) if stored undisturbed for long periods and the bottom fluid may be 3 to 5 percent richer in solution than the top. Thus, the tank should contain an agitator or recirculation unit.

Transportation and Shipping Requirements

Tembind is transported in tanker trailer trucks of 27,000 litre capacity or more. No special precautions are necessary beyond normal transportation of liquids.

Spill Procedures

In accordance with Part 9, Section 79 of the Environment Protection Act, a spill is defined as any discharge, intentional or unintentional, of material from its containing unit beyond the recommended maximum application rate, into the natural environment. This can be caused by spray bars left on after operation, tank rupture, tank overturn, etc. In the event of a spill the following procedures are recommended:

1. Further loss of product should be limited or halted.

2. The following people/organizations should be contacted:

   - The Ministry of the Environment at the Spills Action Centre 1-(800)-268-6060.
   - Environment Canada at The Ontario Regional Environmental Emergencies line: (416)-973-1059, or (416)-346-1971 (cellular).
   - The contractor management.
   - The local municipality.
   - The owner/lessee of the vehicle and/or the shipper/owner of the product.
   - Temfibre emergency numbers:

     - North Bay Terminal: (800) 461-7310 or (705) 495-2195
     - Temiscaming: (819) 627-9505
     - After Hours: (819) 627-3321

SOURCE DESCRIPTION AND QUALITY CONTROL

Tembind A-002 is manufactured from spent sulphite liquor. Initially, ammonia, sulphur dioxide and water are used to cook wood chips (mostly pine and spruce). The sulphur dioxide reacts with wood's lignin to form lignosulphonates, which are removed from the pulp by washing with water. The resulting red liquor is evaporated to remove sulphur dioxide, acetic acid and other volatile compounds to yield a 50 percent solids solution. The liquor is then neutralized with ammonia to a pH between 4.8 to 5.5 to produce Tembind A-002.

Tembind A-002 is only produced when certain grades of pulp are produced at the mill. Solids are controlled to 50 percent (by weight) in the evaporators, as measured by density hydrometers. These numbers are control charted.

The pH is adjusted when the spent sulphite liquor is first received, and again just prior to shipping, if necessary. These numbers are also control charted. Every shipment is also analyzed for viscosity.

Once per year, a sample of Tembind A-002 is sent to a contracted laboratory for analysis of heavy metals and chlorinated organic compounds.

B. TECHNICAL EFFECTIVENESS AND APPLICATION PROCEDURES

TECHNICAL EFFECTIVENESS

Tembind is used primarily as a dust suppressant rather than a road stabilizer.

When Tembind is applied to a road surface, it penetrates the granular material a few centimetres, depending on the porosity of the surface. If the surface is not very porous, penetration is limited to a few millimetres. The portion that penetrates will form a matrix with the fines and smaller granules to bind the surface particles together. The portion that remains on top of the surface forms a crust that resembles a frequently oiled road. Generally, regular maintenance of the road surfaces is required with the use of Tembind, to remove light to medium potholing, which usually occur within 3 to 4 weeks after application. The effectiveness of Tembind and ammonium lignosulphonates in general, depends on climate, traffic, method and level of application.

Rain can reduce the performance of lignosulphonates as dust suppressants. A study conducted by the Ontario Ministry of Transportation (Ontario Ministry of Transportation, June, 1986) included a survey of 24 road agencies, including municipalities in Canada and the U.S., to identify which dust suppressants are used and in what locations. The survey found that lignosulphonates are preferred dust suppressants in more arid regions. Telephone interviews with a range of dust suppressant users in Ontario were conducted by CH2M HILL as part of this study. Users confirmed that drier weather and good road drainage are necessary conditions for achieving acceptable dust suppression performance from lignosulphonates. Since lignosulphonates are water soluble, rain has a tendency to leach the material from the road which shortens the effective lifetime. Therefore, good drainage permits the rain water to be removed as quickly as possible.

Heavy rainfalls may also cause lignosulphonates to pond in puddles and ditches. This was observed during field tests conducted for the Ontario Ministry of Transportation carried out on roads in Southern Ontario using Tembind A-002 (Ontario Ministry of Transportation, January, 1986). No details concerning the amount of rain was recorded. Although weather can have a negative effect on Tembind's effectiveness, the lifetime of Tembind was comparable to that of calcium chloride in this study. A report cited in the 1981 British Columbia Ministry of Transportation survey on Provincial dust suppression practices, indicated an effective lifespan for lignosulphonates from 2 to 3 months in an area that received 292 cm of rain annually. No other site details were presented in this report.

Traffic volume is another variable that can affect the effective lifetime of Tembind. In a Southern Ontario study (Ontario Ministry of Transportation, January 1986) traffic ranged from an average of 50 vehicles per day (ADT or average daily traffic) to 1,039 ADT. The higher traffic volume shortened the effective period of Tembind from 3 to 2 months. The telephone survey also indicated that heavier traffic (dump trucks) accelerates the degradation of the surface dust, and thus reduces the effectiveness of Tembind.

In an Ontario Ministry of Transportation study (June, 1986), field tests compared the performance of Tembind 35, calcium chloride and waste oil on municipal roads in Huntsville, Ontario. Overall results indicated that although the Tembind was fair to good as both a dust suppressant and road stabilizer under the conditions tested, it was the poorest performer of the three. In a study for the Ontario Ministry of the Environment (Acres, 1988) the effectiveness of several dust suppressants on Southern Ontario roads were compared. Effectiveness was defined by stationary measurements of dust emitted from treated road surfaces over a three month period. The study found that Tembind provided dust control similar to the most effective suppressants tested. However, the dust emissions measured from a moving vehicle travelling over the treated surface showed that dust from the road treated with Tembind was twelve times higher than results for the most effective dust suppressants, and twice those of another pulping liquor (also a lignin based product).

In the telephone survey conducted for this study, users reported that a higher fines content (fines are < 200 mesh) in the road surface was beneficial to the effectiveness of Tembind, while sand had a negative effect. Temfibre's technical literature recommends that the road surface fines content be greater than 10 percent for optimum performance. In very porous surfaces, such as one with high sand content, the void spacing and particles are too large preventing a strong matrix from forming.

Tembind, and ammonium lignosulphonates in general, are accepted as dust suppressants across Canada and have been shown to be similar in performance to calcium chloride under a variety of conditions. Unfortunately, a comprehensive performance evaluation of Tembind cannot be made because detailed information about weather conditions, road characterization, etc., has generally not been reported in field studies.

Summary of Overall Effectiveness

1. Generally, of ammonium lignosulphonate treatment of road surfaces is an effective means of dust control if it does not rain within 24 hours of application.

2. Ammonium lignosulphonates will provide the best dust control for the longest periods in arid climates. Ammonium lignosulphonates are soluble in water and may runoff or leach in heavy rain, which reduces their effective lifetime.

3. Effective periods for controlling dust with ammonium lignosulphonates can be up to 3 months for a variety of municipal road traffic volumes.

4. Calcium chloride is often reported in the literature as equal to slightly better than the lignosulphonates in overall performance.

5. Ammonium lignosulphonate may not perform as well as a dust suppressant and stabilizer for roads that have a significant portion of the traffic generated from heavy trucks and equipment.

6. Tembind is effective as a dust suppressant in soil types with higher fines than would be recommended for calcium chloride use. Sand limits Tembind's ability to form a matrix with the surface materials thus reducing its effectiveness.

APPLICATION PROCEDURES

Site Restrictions

Caution is advised when applying lignosulphonates near trout spawning areas to prevent runoff. According to the Ontario Ministry of Environment's Draft Guidelines for the Application of Dust Suppressants, product dust suppressants should not be applied to sites closely adjacent to or crossing waterway(s) or marshes, or near wells.

Surface Preparation

There are several ways to prepare the road for application of Tembind. The methods generally include: initial grading of the surface to remove potholes, corrugations, and to loosen the surface material, and spraying the Tembind in layers and allowing it to penetrate the surface. Some methods suggest a second grading before the last spray to remix the road material and Tembind.

The following are two methods of application that have been tested by the Ontario Ministry of Transportation (Ontario Ministry of Transportation, June, 1986) using Tembind 35. Each method contains road preparation steps. Although no conclusions were drawn in the study report, results suggest that these two methods of application provide optimum performance of Tembind 35.

Application Method 1

1. The road surface should be graded 7.6 cm deep to remove all corrugations, potholes, and to loosen the road surface material to the penetration depth desired.

2. The road should be graded 5.0 cm deep in a manner to leave a windrow on both sides. The distance between the windrow should be 6.1 m wide.

3. The road surface between the windrows should be sprayed at a recommended application rate of 0.91 L/m^2.

4. The road surface should be graded 5.0 cm deep from the right side to the left side and back to the right side, in the same manner as mixing mulch. It might be necessary to make an extra pass with the grader to mix and level the material properly.

5. The road surface should be sprayed again 6.1 m wide at a recommended application rate of 0.91 L/m.

6. The road surface should be regraded 5.0 cm deep from the left to the right side and back to the left side, in the same manner as mixing mulch. Again it might be necessary to make an extra pass with the grader to mix and level the material properly.

7. The finished grade should be left with a crown of 4.2 cm per m from the centre-line to the edge of the road.

8. The dust control product should again be sprayed on the finished grade 6.7 m wide, at a recommended application rate of 0.91 L/m^2.

Application Method 2

1. The road surface should be graded 7.6 cm deep to get rid of all corrugations, pot-holes, and to loosen the road surface material to the penetration depth desired.

2. The road surface should be sprayed 6.1 m wide at the recommended application rate of 0.91 m/L^2.

3. The dust control product should be allowed to penetrate into the road surface.

4. The road surface should again be sprayed 6.1 m wide at the recommended application rate of 0.91 L/m^2.

5. The dust control product should again be allowed to penetrate into the road surface.

6. The road surface should be graded approximately 2.5 cm deep, leaving the finished grade with a crown of 4.2 cm per m from the centre-line to the edge of the road.

7. The dust control product should be sprayed on the finished grade 6.7 m wide at the recommended application rate of 0.91 L/m^2.

Length of Time Before and After Precipitation

Application of Tembind is generally made about 6 to 12 hours after a significant rainfall, depending on the time of year. Application should be made 12 to 24 hours before the next rainfall, depending on humidity, to permit curing and hardening of the surface, and to prevent leaching and runoff.

Equipment

The manufacturer suggests application with a 27,000 litre tanker truck, 275 kPa (40 psi) spray motor and 3.6 m, 7.62 cm Schedule 40 spray pipe (Temfibre, 1991). Ontario has similar requirements for the application of lignosulphonates which were outlined by the Ontario Ministry of Transportation (1988). British Columbia also provides a comprehensive equipment list. An equipment list based on the above sources includes:

- A pressure distributor which is self propelled and capable of maintaining any speed required for spraying.
- A quick opening gate in the dome.
- An external readily visible depth gauge with 50 litre accuracy.
- A pump capable of supplying the required constant manifold pressure.
- Rear mounted spray bars and nozzles 1 to 3 m wide capable of:
  - vertical and lateral adjustment
  - instant shut off
  - spraying of the shoulder
  - producing double coverage in one pass.
- Spray bars that do not extend into the lane of opposing traffic unless adequate warning measures are taken.
- Spray bars equipped with pressure gauges accurate to 15 kPa.
- A dipstick calibrated in 200 L increments.
- The feed to the spray bars equipped with:
  - recirculation before and during operation
  - filters.
- Spray nozzles:
  - fitted with instant on/off valves and,
  - which yield fan-shaped sprays without atomization.

- Splash guards for shoulder spraying.
- A pressure pump capable of applying a minimum of 120 litres of material per minute per meter spray bar.
- An operator visible 15 kPa pressure gauge.
- An operator visible flow meter.
- An operator visible fifth wheel tachometer calibrated in meters per minute.

Personnel Requirements

Typically, two to four people are required for safe application. This would consist of at least one, maybe two, flag persons and/or operator of a pilot warning vehicle, the application truck operator, and a application checker (however, the flag person can double as this person).

Dilution

Tembind is shipped to its applicators as a 50 percent solids solution. At the applicator's storage facility Tembind is diluted with water to the required solution strength prior to transportation to the site. Typical dilutions yield the 25 to 35 percent solids concentrations. Higher concentrations have been used in the past for surfaces with higher sand contents. However, this practice is now not common.

Tembind should not be heated to temperatures above 200 °C or mixed with any materials other than water.

Application Rate and Frequency

Recommended rates of application for Tembind vary depending on the location and solution strength. Generally, Temfibre recommends an application rate of 1 L/m^2 of Tembind 25 for the initial application (or 0.71 L/m^2 of Tembind 35), while results of Southern Ontario field tests (Ontario Ministry of Transportation, January, 1986) indicated that 2.2 L/m^2 of Tembind 35 would provide the optimum performance. This would be applied in 2 or 3 stages to permit proper wetting of road materials and prevent runoff. Too heavy a single application (about 1.58 L/m^2 depending on surface porosity) causes runoff. Another report on tests in Huntsville, Ontario (Ontario Ministry of Transportation, June, 1986) reported total application levels of 2.73 L/m^2, of Tembind 35 applied in 3 stages. The above mentioned numbers are tabulated below for comparison.

It should be noted that only Temfibre provides yearly application guidelines for subsequent road treatments while other studies provide application guidelines per treatment. Application rates can be scaled up or down depending on the Tembind concentration.

Temfibre Seasonal Application Data[1]
Tembind 25

Average Daily Traffic	Number of Applications of Tembind Per Year (25% Solids Solution)	L/m²		
		Initial	Second	Third
<100	2	0.71	0.36	-
100-250	3	0.71	0.36	0.36
250	3	0.71	0.71	0.36

Notes:

1. Temfibre recommendations for seasonal application.

Suggested Applications Per Treatment
Tembind 35

Total Application L/m²	Application Rate (35% Solids Solution)		
	First Step L/m²	Second Step L/m²	Third Step L/m²
2.2[1]	0.73	0.73	0.73
2.2[1]	1.1	1.1	0
2.73[2]	0.91	0.91	0.91

Notes:

1. Aquin, 1986
2. McDougall, 1986

Generally, contractors in Ontario are applying Tembind 25 with satisfactory results.

Ponding should be avoided during application. Ponding will depend on several factors including the rate of Tembind discharge, the speed of the application truck, and the porosity of the surface materials. Ponding can be prevented by shutting off the spray bars when the vehicle/truck is stopped or is passing over paved/sealed portions of the road. Care should also be taken to ensure that the liquid is applied at or below the

suggested rates. If ponding still occurs then a decrease in the application rate is necessary.

Curing Time

Complete curing time is anywhere from 12 to 24 hours. Traffic can be permitted onto fresh surfaces, but it has been suggested that speeds be reduced for at least 2 hours.

C. PHYSICAL AND CHEMICAL CHARACTERISTICS

PHYSICAL PROPERTIES

Physical properties of Tembind 25 are presented in Table 1.

Table 1
Physical Property of Tembind 25

Property	25 Percent Solids
Odour	Woody smell
Appearance	Dark brown solution
Physical state when applied	Liquid
Physical state when dried	Dark brown crust
Solubility in water	Complete
Melting point	-5 °C
Boiling point	105 °C
Viscosity	200 cp
Density	1,230 kg/m^3 @ 25°C (48% solution)

Source: Tembind A-002 Material Safety Data Sheet, no date.

COMPOSITION AND CHEMICAL PROPERTIES

Table 2 presents a breakdown of the main components of solids present in Tembind A-002, as provided by Temfibre.

Samples of seven batches of Tembind 25 were provided by Temfibre Inc. for this study. The samples were composited and the composite was split for duplicate analysis of chemical components including conventional parameters, metals, total phenols and dioxins and furans, at CANVIRO Analytical Laboratories Ltd. The average results of the duplicate analyses are presented in Table 3 for most chemical components. Results for dioxins and furans for duplicate analyses are presented in Table 4.

Table 2 Components of Solids in Tembind	
Properties	**Percent (by weight)[1]**
Lignin content	65%
Reducing Bodies	22%
HPLC sugars	17%
Methoxyl	7.1%
Nitrogen	5%
Sulphur	6%
Sodium	0
Calcium	0
Iron	20 mg/L
Ash	0.5

Sources: Temfibre Inc.

Notes:

1. Percentages do not add up to 100 because categories overlap.

The Tembind 25 solution contains 24,830 mg/L of BOD_5, 1,150 mg/L of ammonia and 105 mg/L of phosphorus. Oil and grease levels were 810 mg/L. A few metals were detected, most in concentrations less than 1 mg/L. Concentrations of manganese, zinc and aluminum did, however, exceed 1 mg/L. In the dioxin/furan analyses, only octachlorodibenzodioxin was detected in duplicate samples at an average toxicity equivalency (TEQ) concentration of 0.003 ng TEQ/L.

D. ACUTE TOXICITY AND SUB-LETHAL EFFECTS

ACUTE TOXICITY

B.A.R. Environmental conducted duplicate acute toxicity tests for Tembind 25 using the same sample analyzed by CANVIRO. The test measured the LC50 values and their corresponding 95 percent confidence interval on the test species rainbow trout and Daphnia magna. The LC50 is the median lethal concentration (i.e. the concentration of the test chemical in water that is estimated to be lethal to 50 percent of the test organism within a prescribed period of time).

Acute toxicity results for the Tembind samples tested are presented in Table 5.

According to one rating system (IMCO/FAO/UNESCO/WHO, 1969), Tembind 25 toxicity rates a Grade 2 on a scale of 0 to 4, where 0 is the least toxic.

Table 3
Chemical Characteristics of Tembind 25[1]

	Units	Concentration
Conventional Parameters		
pH		4.7
Total Solids	mg/L	281,000
BOD_5	mg/L	24,830
Ammonia-N	mg/L	1,150
Total Phosphorus	mg/L	106
Oil & Grease	mg/L	810
Phenols	mg/L	<1
Metals		
Aluminum	mg/L	3.815
Boron	mg/L	0.465
Barium	mg/L	0.365
Beryllium	mg/L	<0.005
Cadmium	mg/L	0.034
Calcium	mg/L	156.5
Chromium	mg/L	0.085
Cobalt	mg/L	<0.03
Copper	mg/L	0.305
Iron	mg/L	5.61
Lead	mg/L	<0.1
Magnesium	mg/L	31.35
Manganese	mg/L	14.7
Vanadium	mg/L	<0.01
Zinc	mg/L	1.2
Nickel	mg/L	0.21
Silver	mg/L	<0.02
Strontium	mg/L	0.695
Sodium	mg/L	<5
Arsenic	mg/L	<0.05
Selenium	mg/L	0.02
Mercury	mg/L	<0.001

Notes:

1. Average of duplicate analyses of composite sample of Tembind 25 (25 percent solids solution) provided by Temfibre.

<: Below the analytical detection limits.

Table 4
Chemical Characteristics Dioxins and Furans of Tembind 25

	Units	ITEF	Sample A[2]		Sample B[2]	
			TEQ	Concentration	TEQ	Concentration
Dioxins and Furans						
TCDD	ng/L	1.0	0.000	<1.7	0.000	<1.4
TCDF	ng/L	0.1	0.000	<1.3	0.000	<1.1
PCDD	ng/L	0.5	0.000	<2.2	0.000	<1.7
PCDF	ng/L	0.5	0.000	<1.6	0.000	<1.2
H6CDD	ng/L	0.1	0.000	<4.0	0.000	<2.6
H6CDF	ng/L	0.1	0.000	<3.1	0.000	<2.1
H7CDD	ng/L	0.01	0.000	<9.9	0.022	TR
H7CDF	ng/L	0.01	0.000	<2.7	0.000	<1.2
OCDD	ng/L	0.001	0.032	3.2	0.029	2.9
OCDF	ng/L	0.001	0.000	<1.8	0.0249	<1.4
Total			0.0032		0.0249	

Notes:

1. Average of duplicate analyses of composite sample of Tembind 25 (25 percent solids solution) provided by Temfibre.
2. Samples A and B are duplicate samples.

TR: Trace amounts detected
<: Below Detection Limit
ITEF: International Toxicity Equivalently Factor.
TEQ: Toxicity equivalent.

Table 5
Acute Toxicity Test Results for Tembind 25

Test Species	Length of test period (h)	Effect	Lethal Concentration (mg/L)	95% Confidence Interval (mg/L)
Rainbow Trout	96	LC50	657	589-731
Daphnia magna	48	LC50	3,536	2,500-5,000

SUBLETHAL EFFECTS

Information on the sub-lethal effects of Tembind was not identified in the information search. To assess the potential sub-lethal effects of this material, each individual chemical component present at concentrations above the guidelines and standards for drinking water and/or aquatic life as presented in Table 6, was examined.

Comparing the conc ntrations of toxic substances in 100 percent strength of the dust suppressant product provides an indication of toxicity to human and aquatic life only on a "worst case" basis. Some dilution effects will occur once the material is released to

land and exposed to the effects of runoff, leaching and degradation. In addition, concentration of persistent substances after repeated application may also occur. The exact extent of dilution or build-up will depend largely on site specific factors and will not be addressed in generic assessments of sub-lethal effects.

In the absence of a detailed exposure and risk assessment, it is not possible to completely assess the degree of human or environmental health risk posed by the use of Tembind for road dust suppression. The following discussion attempts only to identify the contaminants of concern which could potentially cause problems over the long term. In many cases, the toxological data available is limited.

Table 6
Comparison of Contaminant Limits for Drinking Water and Aquatic Life to Concentrations in Tembind 25[1]

Parameter	Aquatic Life	Drinking Water	Tembind 25
Ammonia (mg/L)	0.02 (unionized)[2]	N/A	1,150
Phosphorus (mg/L)	0.02[2]	N/A	106
Aluminum (µg/L)	5-100[2,4]	200[5]	3,815
Cadmium (µg/L)	20[2]	5[2,3]	34
Iron (µg/L)	300[2]	300[2,3]	5,610
Manganese (µg/L)	N/A	50, 500[3], 100[5]	14,700
Nickel (µg/L)	25[2], 25-150[4]	N/A	210
Dioxins & Furans (pg. TEQ/L)	N/A	15[9]	3.2-24.9

Notes:

1. Only parameters with concentrations exceeding referenced limits are presented.
2. Ontario Ministry of the Environment, 1984. Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.
3. Health and Welfare Canada, 1987. Canadian Guidelines for Drinking Water Quality.
4. Environment Canada & Health and Welfare Canada, 1991. How safe is our water?
5. World Health Organization, 1984. Guidelines for Drinking Water Quality, Volume 2 Health Criteria and other supporting information.
6. U.S.S.R. Cited from W.H.O. literature.
7. E.P.A. Cited form W.H.O. literature.
8. Health and Welfare Canada. 1991, Personal Communication.
9. Cited from M.O.E. literature.

Main Components

Tembind ammonia base is not acutely toxic to humans. The oral LD50 is 20,000 mg/kg of body weight for rats (Tembind MSDS, 1988). The lowest published lethal dose of lignosulfonates for mice (intravenous) is 500 mg/kg (RTECS Database, 1991). Due to the low volatility, this product causes no eye irritation. However, minor temporary irritation is possible if there is direct contact with eyes. There is no irritation effect on skin (Tembind MSDS, 1988).

Component Based Assessment

The carbonaceous (BOD5) and nitrogenous (ammonia) oxygen demand of Tembind could reduce dissolved oxygen in surface waters. Oxygen concentrations of 4 to 8 mg/L (depending on temperature) are necessary for freshwater aquatic life (MOE, 1984). Colour and the quantity of suspended solids in water are also increased by the addition of Road Binder. Since colour reduces light penetration to the water, this in turn reduces the photosynthetic action of aquatic flora. Phosphorus in surface water may promote noxious algae growth. Lignosulphonate is moderately toxic to fish (lignosulphonate MSDS, 1988). Effects of these components should not be a concern under normal dust suppressant use, and as long as care is taken not to apply the material in vicinity of surface water.

A number of metals measured in Tembind exceeded the relevant guidelines, however, only a few of these might be of human or environmental concern. Aluminum, cadmium and iron are not likely to be of any harm unless ingested in massive amounts. Nickel is a probable human carcinogen, but only due to inhalation of to nickel dust in occupational settings. Manganese concentrations relating to health concerns are much higher than those related to aesthetic considerations, upon which water quality guidelines are based. Some metals present may bioaccumulate in aquatic biota or plants. Again, toxic or sub-lethal effects of metals will be unlikely if care is taken not to apply Tembind in the immediate vicinity of surface water.

The toxicity equivalencies (TEQ) for dioxins and furans in the Tembind sample are only slightly higher than drinking water guidelines. These guidelines are based on lifetime consumption of 1.5 L water per day and incorporate large safety factors. Thus, the levels present in Road Binder do not warrant concern to human health.

SUMMARY

The following points summarize the acute toxicity and sub-lethal effects for Tembind.

- The lethal dosage of Tembind 25 to rainbow trout is 657 mg/L and to Daphnia magna is 3,536 mg/L.

- Tembind (48 percent solution) is lethal (LD50) to rats at a concentration of 20 g/kg (LD50).

- Several metals (Al, Cd, Fe, Mn and Ni) are present in Tembind 25 at concentrations above available guidelines and standards for drinking water and/or aquatic life. These would not likely pose concern to human or animal toxicity.

- Effects of biochemical oxygen demand, phosphorus, and colour are not likely to be a concern if care is taken not to apply road binder in the vicinity of surface water.

- Dioxins and furans detected in Tembind samples were not at concentrations significant to toxological effects of the material.

E. ENVIRONMENTAL IMPACTS

MAIN DUST SUPPRESSANT COMPONENTS

The main components of Tembind include sugars (17%), reducing bodies (5%), and lignins (65%), with the balance consisting of ammonia, sulphates, etc.

A study sponsored by Temfibre (Anestis, 1989) evaluated the sugar and lignin concentrations from road and ditch samples after application. Sugar levels (glucose) decreased to normal background levels of zero (0) within 144 hours. However, lignin levels remained measurably higher than background levels even after 672 hours (about 4 times higher : 0.76 g/L vs 0.018 g/L).

Lignin itself is very stable in the biosphere. Fungi (of varying types) seem to be best at metabolizing the lignosulphonate structure, although complete metabolism never occurs (School of Public Health, 1982). Lignosulphonates are not particularly volatile and do not pose airborne contamination problems.

Lignosulphonates do not leach appreciably through soils. They are very water soluble and thus pose a water pollution migration problem. With increased rainfall, more lignosulphonates are carried away in storm runoff. Clay holds lignosulphonate most tightly of all soil materials; however, in the pressure of passing water, some does resolubilize and migrate.

Commenting on a study conducted in Sweden, the School Public Health (1982) reports that concentrations of lignosulphonates downstream from paper mills were 10 times higher in surface water than in bottom waters (10 to 20 mg/L vs 1 to 2 mg/L). Furthermore, larger particles of lignosulphonates would deposit in benthic areas or in sediments while finer particles would be carried longer distances.

When injected into the water stream, lignosulphonates pose a pollution problem by causing excessive foaming and discolouration of receiving waters. Discolouration may result in a reduction in the amount of biological activity caused by a reduction in available sunlight (School of Public Health, 1982).

The presence or lignosulphonates in surface water may also affect aquatic organisms living at the lower level. The reduced sunlight reduces the photosynthetic activity of algae, thus reducing the oxygen supply from that source. In addition, the surface of

lignosulphonates is negatively charged, which attracts proteins, making them heavier and more insoluble, causing them to settle out on the bottom, further increasing the oxygen demand at lower levels (School of Public Health, 1984).

COMPONENT BASED ASSESSMENT

The following discussions focus on the environmental impacts of the various contaminants identified in Tembind, including:

- Metals
- Ammonia
- Phosphorus
- Oxygen Demand (BOD_5)
- Dioxins

Metals

None of the levels of metal contaminants found in the Tembind 25 analyzed for this study exceeded background or soil clean-up concentrations for soils. A study for the Ontario Ministry of the Environment (Acres, 1988) found manganese and selenium levels of 46 mg/L and 5 mg/L respectively in an unspecified Tembind product. In this case, the selenium level was higher than the soil background level of 2 mg/kg. However, none of the other metals tested exceeded any standards. Furthermore, metals levels in road material, road ditch material and vegetation from a site treated with Tembind were not significantly different from background levels. The results indicate that Tembind did not increase soil metal levels under normal use. However, long term effects of metals build-up in treated soils and surrounding areas have not been measured.

Ammonia Nitrogen

The Tembind 25 sample tested for this study contained 1,150 mg/L of ammonia nitrogen. Tembind solids include 5 percent nitrogen by weight.

In a study for the Ontario Ministry of Transportation (1986), ammonia, total kjeldahl nitrogen (TKN), dissolved organic carbon and dissolved inorganic carbon levels were monitored in water samples from a stream within 1 m from a road treated with Tembind. Water was sampled at up to 3 locations, prior to spraying, within one hour after application and again after a significantly heavy rainfall five weeks after application. While the results for all parameters varied slightly between sampling locations, there was no evidence of nitrogen or dissolved carbon contamination from an outside source in samples collected after spraying or after rainfall.

Ammonia released to land will evaporate rapidly in the initial stages. Once in the air, ammonia may be subject to some oxidation and may thus contribute to acid rain. In addition, it combines with sulphate and returns to the soil via rainfall washout. Its residence time in the air is short (5 to 10 days). However, since it is essentially miscible with water, some of it will penetrate into the soil. Adsorption to soil particles does occur, especially onto clay minerals, but this adsorption is reversible and subsequent leaching of the ammonia will occur. Thus, reversible adsorption provides some retardation of the ammonia transport rate in groundwater. Biodegradation in soil also occurs and the resulting nitrate is more highly mobile in the soil. Under anaerobic conditions in water, ammonia will accumulate, but will oxidize to nitrate and nitrite under aerobic conditions.

Phosphorus

The total concentration of phosphorus in Tembind 35 was measured to be 106 mg/L. Phosphates released to land will rapidly runoff under saturated soil conditions. Downward movement will occur when soil is not completely saturated. In the soil, adsorption to soil particles is possible but not a dominant fate mechanism. Most phosphates penetrating the soil will be carried with the groundwater. Phosphates are indefinitely persistent in both surface and groundwater. They are nutrients for aquatic life and can stimulate increased growth of algae. Excess amounts contribute to long term eutrophication. No phosphates will enter the atmosphere from a release to land. Phosphates are neither bioaccumulative nor bioconcentrative.

Oxygen Demand

Both ammonia and carbonaceous matter, represented by BOD_5, would contribute an oxygen demand, thus reducing dissolved oxygen concentrations in waterways affected. Fresh water aquatic organisms require a dissolved oxygen concentration between 4 to 8 mg/L (Ontario Ministry of the Environment, 1984). Caution has been advised for dust suppressant application, especially for the use of lignosulphonates near trout spawning areas, for these reasons (Ontario Ministry of Transportation, 1986).

Dioxins

Toxicity equivalencies (TEQ) for the duplicate Tembind 25 samples measured for the study ranged from 0.003 to 0.025 ng/L. Soil assessment criteria for contaminated sites is 1,000 ng TEQ/L, which is 4 to 5 orders of magnitude higher than sample concentrations.

SUMMARY

The following points summarize the environmental impacts associated with the use of Tembind as a dust suppressant:

- Field studies of Tembind have show that sugar levels returned to background levels within 144 hours of application, while lignin levels remained four times higher than background levels even after 672 hours.

- Lignin itself is stable in the biosphere and will not volatilize nor leach appreciably through soils. The main mode of migration is through water because of its high solubility.

- Lignosulphonates in streams may cause discolouration and foaming, and result in reduced aquatic biological activity and available oxygen.

- Metals present in Tembind 25 do not appear to affect background levels in road materials and surrounding areas.

- Dioxins in Tembind 25 are present at levels 4 to 5 orders of magnitude less than soil assessment criteria for contaminated sites.

- In one study, ammonia and TKN concentrations were not increased in surface waters very near roads treated Tembind, even after significant rainfall.

- Most of the ammonia in Tembind applied to roads will evaporate rapidly to the air. Ammonia remaining is readily soluble, and will be carried with runoff to soils and streams where it will biodegraded or be used as nutrient for vegetation.

- Both ammonia and carbonaceous components of Tembind would deplete oxygen in surface waters if present. Phosphorus in Tembind would promote noxious algal growth.

Temfibre INC.

C.P. 3000 TEMISCAMING (QUEBEC)
CANADA J0Z 3R0
TEL. 819-627-9505
TEX. 067-76281
FAX. 819-627-3622

MATERIAL SAFETY DATA SHEET

SECTION I

Chemical Name	:	Lignin Sulfonates
Trade Name	:	Tembind A, S, K, Temsperse S, K
Chemical Family	:	Salts of lignin sulfonic acids.
Formula	:	Polymeric form of lignosulfonic acids with ammoniumm, soidium or potassium as cations.
CAS Registry No.	:	Ammonia base - 8061-53-8 (lignosulfonic acid ammonium salt)
		Sodium base - 8061-51-6 (lignosulfonic aicd sodium salt)

SECTION II - PHYSICAL DATA

Boiling point	:	105°C
Melting point	:	-5°C
Specific gravity @ 25°C	:	1.23 (of a 48% solution)
Solubility in water	:	Liquid - complete; powder - 550 g/l
Appearance and odor	:	Brown powder, dark brown solution. Woody smell

SECTION III - FIRE AND EXPLOSION HAZARD DATA

Flash point	:	n/a
Auto ignition temperature	:	n/a
Extinguishing media	:	Water, foams, dry powder, carbon dioxide.

SECTION IV - HEALTH HAZARD DATA

Threshold limit value (TLV)	:	None known
LD50	:	Tembind A - 20,000 mg/kg of body weight for rats.
Eye irritation:	:	None (very low V.P.)
Skin irritation:	:	None
Effects of over exposur	:	None
Eye contact:	:	Minor temprary irritations possible.
Skin contact:	:	None
Inhalation:	:	Not applicable
Ingestion:	:	Not applicable

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SECTION V - REACTIVITY DATA

Stability (Thermal,light,etc)	:	Stable
Conditions to avoid	:	None
Hazardous polyermization	:	Will not occur
Conditions to avoid	:	None
Incompatability (Materials to avoid)	:	None
Hazardous decomposition products	:	Sulfur dioxide released from burning. Ammonia released from strong alkaline addition

SECTION VI - SPILL OR LEAK PROCEDURES

Precautions if material is released or spilled	:	Normal sweeping, vacuuming or washing with water
Waste disposal methods	:	Domestic or industrial sewers

SECTION VII - SPECIAL PROTECTION INFORMATION

Eye protection	:	Goggles preferable but not necessary
Respiratory protection	:	Face mask preferable but not necessary (dust problem for powders only)
Skin Protection	:	Not necessary
Ventilation	:	Dust problem only

SECTION VIII - SPECIAL PRECAUTIONS

Handling and Storage	:	None

SECTION IX - SHIPPING REGULATIONS

These are non-hazardous materials and therefore no special handling regulations are applicable.

APPENDIX E.4

Domtar Road Binder

REVIEW PARAMETER LIST FOR DOMTAR ROAD BINDER

A. GENERAL INFORMATION

Road Binder is a sodium carbonate based spent pulping liquor from Domtar Packaging containing from 10 to 30 percent solids. It is a black/brown liquid with a faint woody smell. Road Binder is a solution of short-chain carboxylates, polysaccharides, lignin, and lignin breakdown products, sodium carbonate, and suspended solids (wood and bark fragments). In addition to dust suppression, Road Binder may also be used as boiler fuel at Domtar's Cornwall facility.

SUPPLIER/DISTRIBUTOR INFORMATION

Manufacturer/Supplier

Domtar Packaging
Container Board Division
Trenton Mill
Trenton, Ontario

Contact: Jim McKee
Telephone: (613) 392-6505

Domtar produces and distributes Road Binder.

Applicators

Jim McKee of Domtar (613) 392-6505 can be contacted for information on applicators of Road Binder for dust suppression.

COST INFORMATION

Road Binder is provided by Domtar free of charge to local municipalities and their applicators.

Road Binder is usually applied by the local municipalities and costs range from less than an estimated \$0.01 per m^2 to \$0.02 per m^2 per season (1991) depending on distance from Domtar and labour expenses. Municipalities may use their own equipment for application. If a contractor is used, similar costs are incurred.

SAFETY PROCEDURES

Personal Protection

Since Road Binder is a biodegradable, non-corrosive product, minimal protection is required when handling. Domtar recommends gloves impervious to aqueous mixtures, and safety glasses or goggles be worn when during handling.

Emergency First Aid

Emergency first aid procedures are listed in the attached Material Safety Data Sheet for Road Binder.

Storage Requirements

Road Binder should be stored in open containers and/or be well ventilated. Caution should be exercised when opening sealed containers since microbial activity may cause accumulation of combustible gas.

If Road Binder is stored undisturbed for a lengthy period, it may stratify. Therefore, the liquid should be periodically stirred or recirculated to ensure uniform concentrations throughout the tank.

Transportation and Shipping Requirements

Road Binder is transported by Domtar in 8,200 litre and 12,700 litre tanks supplied by Domtar for single and double axle dump trucks, or municipal tanker trucks.

Since Road Binder is currently classified as a liquid industrial waste in Ontario, each load must be accompanied by a Provincial manifest. Correspondingly, the equipment used to haul each load must meet the approved standards prescribed under Ontario Regulation 309.

Spill Procedures

In accordance with Part 9, Section 79 of the Environment Protection Act, a spill is defined as any discharge, intentional or unintentional, of material from its containing unit beyond the recommended maximum application into the natural environment. This can be caused by spray bars left on after operation, tank rupture, tank overturn, etc. In the event of a spill the following procedures are recommended:

1. If possible, the spilled Road Binder should be contained in a ditch or within the road allowance, and prevented from entering watercourses and storm sewers.

2. The following persons should be notified immediately (in the order set out):

   - The Ontario Ministry of the Environment at this number: Spills Action Centre 1-800-268-6060;

   - Environment Canada at The Ontario Regional Environmental Emergencies line: (416)-973-1059, or (416)-346-1971 (cellular);

   - The municipality in which the spill occurred;

   - The foreman or supervisor; and

   - Domtar Packaging at the Trenton Mill at:

     - Mr. Jim McKee - 7:30 am to 4:30 pm - (613) 392-6505
     - Production Foreman - After Hours - (613) 392-6505

3. Operators should take appropriate action to contain the spill as follows:

   - Operators should make arrangements to have a vacuum sump truck attend at the site to remove all Road Binder which has collected in pools or ditches.

   - Objects, articles, buildings or vehicles which were splashed with Road Binder in the spill event should be cleaned with water.

   - Lawns and other landscape and garden plants should be flushed with large volumes of water.

SOURCE DESCRIPTION AND QUALITY CONTROL

At the Domtar Packaging plant in Trenton, Ontario, wood chips are cooked in steam at a pressure of 1,100 kPa in the presence of a mild solution of sodium carbonate (115 g/L) for 14 minutes. During the sodium carbonate process, the chips are softened so that they can be subsequently separated into individual fibres during the refining stage. Following this process, the chips are compressed to remove most of the soluble material. The separated liquid is evaporated to produce a solution with 10 to 30 percent solids, which is Road Binder.

Road Binder's quality is controlled in the evaporators. Following the evaporation stage, Road Binder is pumped to a clay lined holding pond. No control is exercised over dilution from runoff or rain into the holding pond. Typically the pond concentration is between 10 and 20 percent solids.

Domtar may also divert pulping liquor at controlled solids concentrations to holding tanks. This diverted material is referred to as Dombind, an alternative dust suppressant.

Trucks pull up to the pumping station to draw Road Binder from the ponds. Municipalities will often prefer to transport the more concentrated form (30 to 40 percent solids) if they are transporting over long distances to their municipalities. Dilution of product to the recommended 20 to 25 percent solids then occurs at the applicators holding site.

B. TECHNICAL EFFECTIVENESS AND APPLICATION PROCEDURES

TECHNICAL EFFECTIVENESS

Domtar's Road Binder is typically used as a dust suppressant and road stabilizer. Although the composition of Road Binder is somewhat different from lignosulphonates, it is believed to act in a similar manner.

Road Binder is generally used in and around the Trenton, Ontario area municipalities within an 80 km radius as of 1987, but also as far away as Huntsville, Hamilton, and Milton. It functions primarily by penetrating the surface to a few centimetres and binding the road surface material into a crust. Unlike lignosulphonates, Road Binder does not form a separate lignin surface crust on the road. Effectiveness of the Road Binder is a function of rain, soil composition, and care of application.

Limited information is available on the technical effectiveness of Road Binder. Sources of information include a telephone survey carried out for this study and literature, including technical information from Domtar.

In the telephone survey, Domtar technical personnel and Ontario municipalities that are current users of Road Binder were contacted. The information gathered indicates that hard packed road surfaces prevent the penetration of Road Binder, which prevents the proper and necessary binding of the surface. This makes the Road Binder more susceptible to runoff during periods of rain, reduces effectiveness, and shortens its effective life. In a field study carried for the Ontario Ministry of the Environment, Road Binder only penetrated a few millimetres on a hard packed surface (Acres, 1988). Despite this effect, many municipalities will apply subsequent applications of Road Binder without preparatory grading. This is probably due to the low application costs and free material, and high frequency of application.

Road Binder is not as effective a dust suppressant on surfaces with high sand content. Sandy roads have a porosity that provides Road Binder the opportunity to leach away under rainy conditions. Sand also prevents an adequate level of surface binding, which reduces the dust suppressing ability of the Road Binder. No quantitative surface composition data was provided by users or Domtar's technical staff. However, it has been suggested that lignin based dust suppressants are not as sensitive to fines content as calcium chloride, and generally perform better with higher fine contents (Domtar, November, 1987). Yet, too high a fines content will cause roads to be slippery during rain.

The field study conducted by Acres for the Ontario Ministry of the Environment provided a general comparison of Road Binder's dust suppressing effectiveness to other dust suppressants. This study reported that the overall effectiveness of Road Binder tested on a municipal road in Southern Ontario was so low that it resulted in twice the recommended Provincial dust levels of suspended particles, based on 30 day stationary monitoring. Results from monitoring of dust emitted from the test area taken from a moving vehicle showed that Road Binder was twice as effective in controlling dust as an ammonium lignosulphonate, but less than one sixth as effective as the most effective dust suppressants.

In a report published by Domtar (Domtar, November, 1987), Road Binder was reported to be most suited to low average daily traffic (ADT) volumes, of less than 100 ADT, and moderately suitable to roads with medium traffic conditions (100 to 250 ADT). This level of service was also confirmed in the telephone survey of Ontario municipal users.

Users surveyed also indicated that the period of effectiveness of Road Binder is usually one to four weeks, depending on the location, weather, traffic, and surface application. The length of the effective period of Road Binder is reported to be reduced by rain, since Road Binder is soluble in water and therefore, leaches away during rain events. This makes Road Binder more suited to drier climates/periods.

Summary of Overall Effectiveness

Based on the literature, a number of factors affecting the performance of Road Binder were identified as follows:

1. Penetration of the surface to a few of centimetres is important for performance and longevity of Road Binder's effectiveness.

2. Road Binder is most effective on roads with traffic volumes less than 100 vehicles per day.

3. Road Binder's effective period varies with application, weather and traffic load. Effective periods generally fall within 1 to 4 weeks, but can be as short as a few days.

4. Rain has a negative impact on Road Binder's longevity as an effective dust suppressant since it is soluble in water. Road Binder is more suited to drier climates, as are lignin based products in general.

5. Soil porosity affects Road Binder's effectiveness. High sand concentrations will reduce Road Binder's ability to bind the surface, and will promote leaching during periods of rain. However, low porosity existing as a result of hard packed surfaces prevents penetration of Road Binder into the surface aggregate.

6. Road Binder performs in a consistent manner over a wide range of soil fines content.

APPLICATION PROCEDURES

Site Restrictions

Domtar suggests that Road Binder should not be applied on any bridge or on bridge approaches where the road crosses water courses such as rivers, streams or marshes. In addition, Road Binder should not be applied on any road areas within 30 meters of a well.

According to the Ontario Ministry of Environment's Draft Guidelines for the Application of Dust Suppressants year, they should not be applied to sites closely adjacent to or crossing waterway(s) or marshes, or near wells.

Surface Preparation

Information is not available from Domtar for the preparation of road surfaces prior to Road Binder application. Information presented is based on the telephone survey conducted for this study with Ontario municipalities that are currently using Road Binder.

Road preparation generally involves grading a road in spring to a sufficient depth to remove all potholes and corrugations. Grading also loosens up the surface to provide some porosity which facilitates better penetration of Road Binder. It is important that the road contain some moisture from either rain or watering to facilitate the best grading results.

After grading, the road is sprayed with Road Binder at desired levels. Some municipalities grade the roads before every application while others grade only in the spring and once or twice more throughout the season. If subsequent applications are made because of dust complaints, Road Binder is applied directly to the road without prior grading. Areas of road that have developed potholes and corrugation will receive light grading.

Length of Time Before and After Precipitation

Municipal experience has found that application of Road Binder made while the road surface is dry yet still contains some moisture results in the best performance. Usually, this is about 6 to 12 hours after a significant rainfall, depending on the time of year. Application should be made 12 to 24 hours before the next rainfall, depending on humidity, to permit curing and hardening of the surface. If heavy rains are expected, the product should not be applied until afterwards to prevent leaching and runoff.

Application Equipment

Equipment used to apply Road Binder may be supplied by the applicator, or can be supplied by Domtar. Domtar recommends certain minimum standards of equipment which they supply. These are outlined below (Domtar Instruction Manual):

- Tanks supplied by Domtar that sit on dumptrucks are 8,200 L for single axle dump truck and 13,000 L for tandem axle dump trucks.
- Tanks should contain a top-loading hatch with drop-in cover plates and hinged lock cover over the hatch.
- Road Binder should not be applied from a truck that is noticeably slowing down when travelling uphill to prevent excessive application. Application should be made on downgrades in such cases.
- The discharge line from the tank to the spreader bar should have an air-operated ball valve followed by a manually operated valve just prior to the spreader bar.
- The air-operated ball valve control should be located in the truck cab.
- Spreader bars should have 1.9 cm holes spaced 6.35 cm apart along the underside with a 6.35 cm by 1.9 cm slot in the middle.
- Spreader bars should have threaded caps on the end.
- Spray bars not supplied by Domtar should not extend beyond the edge of the road to avoid shoulder spraying.

The above equipment specifications have been established and approved by Domtar and the municipalities that have used Road Binder. Other equipment specifications that may be considered more comprehensive are those for the application of lignosulphonates, outlined by the Ontario Ministry of Transportation (1988).

These additional requirements are for the pressure distributor. It should be self propelled and capable of maintaining any speed required for spraying, and should have the following equipment:

- A pump capable of supplying the required constant manifold pressure.
- Rear mounted spray bars and nozzles 1 to 3 m wide capable of:
  - vertical and lateral adjustment
  - instant shut off
  - spraying the shoulder
  - producing double coverage in one pass.
- Spray bars equipped with pressure gauges accurate to 15 kPa.
- A dipstick calibrated in 200 L increments.
- The feed to the spray bars equipped with filters.
- Spray nozzles fitted with instant on/off valves and that yield fan-shaped sprays without atomization.
- Splash guards for shoulder spraying.

Personnel Requirements

Typically, two to four people are required for safe application of Road Binder. This would consist of at least one, maybe two, flag person(s) and/or operator(s) of a pilot vehicle (warning vehicle), the application truck operator, and a checker (the flag person can double as a checker). If contractors are used, then only supervision by the customer may be necessary.

Dilution

If concentrated Road Binder (solution 30-40 percent solids) is obtained from Domtar for the purpose of transporting long distances, then dilution with water for a final concentration of 20 to 25 percent solids is suggested for most normal municipal road conditions. Heavier traffic or industrial conditions may warrant the more concentrated solution. It has been suggested by Domtar and the local municipalities that the best results are achieved with the 20 to 25 percent solution.

Domtar's Road Binder should not be mixed with any materials other than water for the purpose of dilution.

Application Rates and Frequency

Road Binder application rates are usually the same for initial and subsequent applications, since the material has a relatively short effective lifetime. Applications are generally from 1.56 L/m^2 (Acres, 1990) to 1.65 L/m^2. Domtar does not have a recommended application frequency. Municipal experience suggests application may be as frequent as every few days to once every month. It is generally accepted that Road Binder is applied as needed.

Ponding should be avoided during application. Note that ponding can result at or below the maximum recommended application rates. Ponding will depend on several factors; the rate of Road Binder discharge, the speed of the application truck, and the porosity of the surface materials. Ponding can be prevented by shutting off the spray bars when the vehicle/truck is stopped or is passing over paved/sealed portions of the road. Care should also be taken to ensure that the liquid is applied at or below the suggested rates. If ponding still occurs, then a decrease in the application rate is necessary.

Curing Time

Curing time of Road Binder varies with climatic conditions. Road Binder dries to the touch within 1/2 hour and can be driven on immediately after application. However, to receive maximum performance, traffic should be reduced in speed, or at best, restricted for a few hours. A period of 24 hours permits complete curing to a hard impervious crust (Domtar, November, 1987).

Problems/Hazards

Heavy rain falls may make roads treated with Road Binder more slippery than untreated roads.

C. PHYSICAL AND CHEMICAL CHARACTERISTICS

PHYSICAL PROPERTIES

Road Binder is typically produced with solids concentrations between 10 to 30 percent, but can be more concentrated if requested. The physical properties for the most concentrated form that would be applied to the road is presented in Table 1.

Table 1 Physical Properties of Road Binder	
Property	**Road Binder 39 Percent Solids**
Odour	woody
Appearance	dark brown liquid
Physical state when applied	liquid
Physical state when dried	solid
pH @ 25°C	8.4
Solubility in water	complete
Vapour pressure relative to water	same
Melting point	0 °C
Boiling point	100 °C
Viscosity @ 25°C	1,400 cp
Specific Gravity	1.1
Source: Data from Material Safety Data Sheet and Product Information Manual for Road Binder.	

COMPONENTS AND CHEMICAL PROPERTIES

A detailed breakdown of the chemical composition of Road Binder has been presented in two reports (Domtar, October, 1987 and November, 1987). Table 2 presents the breakdown of major constituents in Road Binder solids.

These reports also present the breakdown of phenolic compounds in Domtar's Road Binder, as shown in Table 3. Total phenol concentrations were reported to be 231 to 247 mg/L. In a third report (Acres, 1990), the total concentration of phenolic compounds in Road Binder was 166 mg/L. Domtar reports the phenols concentration will vary significantly from batch to batch, depending on the type of wood processed. It has been observed that the highest phenol concentrations result from the processing of poplar tree (Campney, 1991).

One sample of Domtar's Road Binder from the outdoor storage pond and a second from their storage tank were provided for the study. The samples were composited, and the composite sample split for duplicate analyses.

The samples were not diluted. All chemical analyses were carried out by CANVIRO Analytical Laboratories Ltd. The average results for the duplicate samples for most contaminants are presented in Table 4. Results for duplicate samples for the dioxin/furan analyses, are presented in Table 5.

Table 2
Approximate Chemical Composition of Road Binder Solids

Constituent	% in Solids
Inorganic Cations	**18.4**
• Sodium	(17.5)[1]
• Calcium	(0.1)
• Potassium	(0.8)
Inorganic Anions	**3.7**
• Carbonate	(3.3)
Carboxylates	**36.4**
• Oxalate	(0.4)
• Malonate	(1.3)
• Succinate	(2.6)
• Glycolate	(0.2)
• Lactate	(3.7)
• Formate	(5.1)
• Acetate	(21.9)
• 2-Hydroxy-3-methyl butyrate	(8.7)
• Isobutyrate	(0.5)
Polysaccharides	**6.2**
Lignin/Lignosulfonates	7.9
Resin & Fatty Acids	0.1
Phenolics/Extractives	0.7
Suspended Matter	18.3
Unaccounted	8.3

Source:

Domtar, November, 1987 and October, 1987

Notes:

1. Amounts of individual components of the chemical class.

Table 3 Phenols in Domtar Road Binder	
Compound	**Concentration (mg/L)**
Phenol	66
o-Cresol	1.9
m-Cresol	<0.5
p-Cresol	3.1
Guaiacol	6.5
4-Hydroxybenzaldehyde	<7.5
4-Methylguaiacol	44
4-Ethylquaiacol	<1.0
Syringol	61
Vanillin	<1.5
Acetovanillone	13
Syringaldehyde	20
Acetosyringone	16
Total Phenolics	**231-247**
Source: Domtar, October, 1987.	

D. ACUTE TOXICITY AND SUB-LETHAL EFFECTS

ACUTE TOXICITY

B.A.R. Environmental conducted acute toxicity tests on Road Binder. The test measured the LC50 values and their corresponding 95 percent confidence interval on the species rainbow trout and Daphnia magna. The LC50 is the median lethal concentration (i.e. the concentration of the test chemical in water that is estimated to be lethal to 50 percent of the test organism within a prescribed period of time). The same composite undiluted samples used for chemical analyses were used in the toxicity testing. Toxicity test results are presented in Table 6.

According to one rating system (IMCO/FAO/UNESCO/WHO, 1969) Road Binder toxicity rates a Grade 1 on a scale of 0 to 4, where 0 is the least toxic.

At the lethal dose of Road Binder to rainbow trout, the concentration of phenols measured for this study is 60 µg/L. Pathological changes in gulls and fish tissues have been found at concentrations in the range of 20 to 70 µg/L (Reichenback-Klinke, 1965).

Table 4
Chemical Characteristics of Road Binder

	Units	Concentration
Conventional Parameters		
pH		8.7
Total solids	mg/L	232,000
BOD_5	mg/L	114,690
Ammonium Nitrogen	mg/L	177
Total Phosphorus	mg/L	170
Oil & Grease	mg/L	6,900
Phenols	µg/L	14,900
Metals		
Aluminum	mg/L	3.44
Boron	mg/L	2.02
Barium	mg/L	4.45
Beryllium	mg/L	<0.005
Cadmium	mg/L	0.034
Calcium	mg/L	6.34
Chromium	mg/L	0.03
Cobalt	mg/L	<0.03
Copper	mg/L	0.16
Iron	mg/L	2.49
Lead	mg/L	<0.1
Magnesium	mg/L	70.55
Manganese	mg/L	5.67
Vanadium	mg/L	<0.01
Zinc	mg/L	4.16
Nickel	mg/L	0.105
Silver	mg/L	<0.02
Strontium	mg/L	0.255
Sodium	mg/L	16,470
Arsenic	mg/L	<0.05
Selenium	mg/L	0.025
Mercury	mg/L	<0.001

Notes:

* Average of duplicate analyses for composite sample of pulping liquor from Domtar's is holding pond and storage tank.

<: Below detection limit.

Table 5
Chemical Characteristics of Road Binder Dioxins and Furans

Dioxins and Furans	Units	ITEF	Road Binder Sample A		Road Binder Sample B	
			TEQ	Concentration	TEQ	Concentration
TCDD	ng/L	1.0	0.000	<0.3	0.000	<0.6
TCDF	ng/L	0.1	0.000	<0.24	0.000	<0.47
PCDD	ng/L	0.5	0.000	<0.33	0.000	<0.074
PCDF	ng/L	0.5	0.000	<0.23	0.000	<0.27
H6CDD	ng/L	0.1	0.000	<0.57	0.000	<0.85
H6CDF	ng/L	0.1	0.000	<0.45	0.000	<0.67
H7CDD	ng/L	0.01	0.022	TR	0.027	TR
H7CDF	ng/L	0.01	0.000	<0.2	0.000	<1.5
OCDD	ng/L	0.001	0.0014	1.4	0.0018	1.8
OCDF	ng/L	0.0001	0.000	<1.4	0.000	<1.4
Total			0.0234		0.0288	

Notes:

ITEF: International toxicity equivalency factor.
TEQ: Toxic equivalents.
<: Below detection limit.
TR: Trace amounts detected
Samples A and B are duplicate samples

Table 6
Acute Toxicity to Rainbow Trout and Daphnia Magna

Organism	Length of Test Period (h)	Effect	Lethal Concentration mg/L	95% Confidence Interval (mg/L)
Rainbow Trout	96	LC50	4,337	3,877-4,851
Daphnia magna	48	LC50	1,342	1,000-1,800

Other Acute Toxicity Information

Mammalian toxicity data for each of the major carboxylate, fatty acids and phenolic compounds was compiled by Domtar (November, 1987). This data is summarized in Table 7. An overall mammalian toxicity was calculated at 23,000 mg/kg (Domtar, November 1987).

Acute toxicity of Road Binder was measured for a number of aquatic biota (Domtar, October 1987), and results are presented in Table 8. The lethal concentration (96 h) for rainbow trout of 0.7 percent (v/v) compares to 0.4 percent (v/v) measured for this study.

Table 7 Mammalian Toxicity Data for Road Binder	
Compound	**LD50 (mg/kg) Oral Dose for Rats**
Carboxylates	
• Oxalic acid	375[1]
• Sodium oxalate	no data
• Malonic acid	1,310
• Sodium malonate	1,100[1,2]
• Succinic acid	no data
• Sodium succinate	1,900[1]
• Glycolic acid	1,950[1]
• Sodium glycolate	1,900
• Lactic acid	3,730
• Sodium lactate	2,000[1,2]
• Formic acid	1,100[1]
• Acetic acid	3,310[1]
• Sodium acetate	3,530
• 3-Methyl-butyrate	2,000[1]
• Isobutyric acid	280[1]
Fatty Acids	
• Linoleic acid	no data
• Palmitic acid	no data
• Oleic acid	74,000
Phenolics	
• Phenol	394[1]
• Guaiacol	128
• Vanillin	1,580

Notes:

1. Value used for the calculation of the overall toxicity.
2. Intrapertioneal

Reference: NIOSH, 1985.

SUBLETHAL EFFECTS

Information on the sub-lethal effects of Road Binder identified in the information search was limited. To assess the potential sub-lethal effects of this material, each individual chemical component present at the concentrations above the guidelines and standards for drinking water and/or aquatic life, as presented in Table 9, were examined.

Comparing the concentrations of toxic substances in 100 percent strength of the dust suppressant provides an indication of toxicity to human and aquatic life only on a "worst case" basis. Some dilution effects will occur once the material is released to land and

Table 8
Toxicological Testing on Domtar Road Binder

Bioassay				(%, v/v)
Bacteria				
	•	"Microtox"	IC50[1] (5 min)	0.6
	•	"Chromotest"	IC100 (4h)	>5
			EMC[2] (4h)	>5
Daphnids				
	•	Daphnia magna IC50 (24h)		0.8
Algae				
	•	Selenastrum capriconutum IC50 (96h)		0.35
Fish				
	•	Salmo gairdneri	LC50 (96h)	0.7
	•	(Rainbow trout)	LT50[3] (2% v/v)	1.5 h

Notes:

1. Inhibition concentration.
2. Concentration at which genotoxicity is observed.
3. Time period after which 50% of population will survive.

Table 9
Comparison of Contaminant Limits for Drinking Water and Aquatic Life to Concentrations in Road Binder[1]

Parameter	Aquatic Life	Drinking Water	Road Binder
Ammonia (mg/L)	0.02 (unionized)[2]	N/A	177
Phosphorus (mg/L)	0.02[2]	N/A	170
Phenols (µg/L)	1[2]	2[2]	14,900
Aluminum (µg/L)	5-100[2,4]	200[2]	3,440
Barium (µg/L)	n/a	100[6], 1,000[2,3]	4,450
Cadmium (µg/L)	20[2]	5[2,3]	34
Iron (µg/L)	300[2]	300[2,3]	2,490
Manganese (µg/L)	N/A	50[2], 500[3], 100[5]	5,670
Sodium (mg/L)	N/A	200[5]	16,470
Dioxins and furans (pg TEQ/L)	N/A	15[6]	23-29

Notes:

1. Only parameters with concentrations exceeding referenced limits are presented
2. Ontario Ministry of the Environment, 1984. Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.
3. Health and Welfare Canada, 1987. Canadian Guidelines for Drinking Water Quality.
4. Environment Canada & Health and Welfare Canada, 1991. How safe is our water?
5. World Health Organization, 1984. Guidelines for Drinking Water Quality, Volume 2 Health Criteria and other supporting information.
6. Cited from M.O.E. literature

exposed to the effects of runoff, leaching and degradation. In addition, concentration of persistent substances after repeated application may also occur. The exact extent of dilution or build-up will depend largely on site specific factors and will not be addressed in generic assessments of sub-lethal effects.

In the absence of a detailed exposure and risk assessment, it is not possible to completely assess the degree of human or environmental health risk posed by Road Binder. The following discussion attempts only to identify the contaminants of concern which could potentially cause problems over the long term. In many cases, the toxological data available is limited.

Main Components

Information on Domtar Road Binder toxicity was not identified. The only indication of toxicity is that this product would enter human body via skin or eye contact (Domtar Road Binder, MSDS, 1988).

Domtar carried out tests in 1986 to compare the effects of oxidized Road Binder and salt (NaCl) on the germination growth of grass. Grass planted in flats with potting soil was watered with different doses of Road Binder and salt in solution. At concentrations of Road Binder under 4.5 percent (w/v), there was no effect on germination or growth. Higher concentrations resulted in some hindering of germination and altering of growth. All concentrations of sodium chloride above 1.5 percent hindered germination and growth (Domtar, November, 1987).

Contaminant Based Assessment

The carbonaceous (BOD_5) and nitrogenous (ammonia) oxygen demand of Road Binder would reduce dissolved oxygen in surface waters. Oxygen concentrations of 4 to 8 mg/L (depending on temperature) are necessary for freshwater aquatic life (MOE, 1984). Colour and the quantity of suspended solids in water are also increased by the addition of Road Binder. Since colour reduces light penetration to the water, this in turn reduces the photosynthetic action of aquatic flora. Phosphorus in surface waters may promote noxious algae growth. Affects of these components should not be a concern under normal dust suppressant use, and as long as care is taken not to apply the material in the vicinity of surface water.

A number of metals measured in Road Binder exceeded the relevant guidelines; however, only a few of these might be of human or environmental concern. Aluminum, barium, cadmium and iron are not likely to be of any harm to humans unless ingested in massive amounts. These contaminants are not dermally penetrated, and therefore, do not pose safety or handling risks. Manganese concentrations related to health concerns are much higher than those related to aesthetic considerations, upon which drinking water quality guidelines are based. Some of the metals present may bioaccumulate in

aquatic biota or plants. Again, toxic or sub-lethal effects on aquatic life will be unlikely if care is taken not to apply Road Binder in the immediate vicinity of surface water.

Phenolic compounds are toxic to humans at much higher concentrations than drinking water guidelines, which are based on taste and odour thresholds, rather than toxicity. It has been estimated that the daily intake of phenols from air, food and water is 9 mg (Health and Welfare Canada, 1980) compared to 14.9 mg/L in the study sample. Human health concerns related to phenols in Road Binder do not appear to be significant.

Phenolic compounds can effect freshwater fish by direct toxicity, and also by tainting of fish flesh (EIFAC, 1973). Phenolics applied to roads in Road Binder have been shown to migrate little from the application site, and rapidly decrease in concentration through natural degradation and adsorption. Thus, through normal dust suppressant use, toxicity or tainting of aquatic life should not be a concern.

Ill effects to sodium sensitive individuals due to high levels of sodium in drinking water have been documented. High levels of salts such as sodium in surface water may create salinity problems to fresh water biota.

The toxicity equivalencies (TEQ) for dioxins and furans in the Road Binder samples analyzed in the study are only slightly higher than drinking water guidelines. These guidelines are based on lifetime consumption of drinking 1.5 L water per day, and incorporate large safety factors. Thus, the levels present in Road Binder do not warrant concern to human health.

SUMMARY

The following points summarize the acute toxicity and sub-lethal effects of Domtar Road Binder:

- In acute toxicity tests, the lethal dosage of Road Binder was found to be 4,337 mg/L for rainbow trout and 1,342 mg/L for Daphnia magna.

- Based on the toxicity of its components, the mammalian toxicity of Road Binder is estimated at 23,000 mg/kg.

- Several metals (Al, Ba, Cd, Fe and Mn) are present in Road Binder at concentrations above available guidelines and standards for drinking water and or aquatic life. These would not likely pose significant concerns related human or animal toxicity.

- Effects of biochemical oxygen demand, phosphorus, and phenolics on aquatic are not likely to be a concern if care is taken not to apply Road Binder in the vicinity of surface water.

- Road Binder diluted to concentrations of 4.5 percent or less (w/v) applied to grass did not affect germination or growth.

- Dioxins detected in Road Binder samples are not at concentrations significant to the toxological effects of Road Binder.

E. ENVIRONMENTAL IMPACTS

MAIN DUST SUPPRESSANT COMPONENTS

As previously discussed, Road Binder is very viscous, and therefore does not penetrate deeply into road surface materials. When applied, it dries within 24 hours and only the most soluble components leach away when dissolved in rain water. According to Domtar (November, 1987), these represent only a small portion of the total quantity sprayed on the road.

The main components of Road Binder solids listed in Table 2 include the following:

- Sodium and other cations
- Carboxylates, monosaccharides and polysaccharides
- Lignin
- Suspended mater
- Phenols

The environmental impacts of each of these components are discussed below.

Sodium and Other Cations

Approximately 18 percent of the solids concentration of Road Binder is sodium. Other cations present include calcium and potassium, accounting for less than an additional 2 percent.

Sodium is an undesirable contaminant in waters from aquifers and surface water, as well as in soil. Sodium is a problem in the soil solution as a component of total salinity, which at varying levels creates toxicity problems for adsorption. Sodium is also of interest in drinking water, since sodium restricted diets are often recommended to address human health concerns.

Sodium salts present in Road Binder have a very high solubility coefficient, meaning they are readily dissolved in rain water, making sodium the most mobile component of Road Binder (Acres, 1990). It has however, been reported that the quantity of sodium applied to roads by application of Road Binder for dust suppression is two orders of magnitude lower than the amount of sodium released by standard winter road salting practices (Domtar, November 1987).

Calcium and potassium components of Road Binder are readily adsorbed to soil particles.

Carboxylates, Monosaccharides and Polysaccharides

A large component of Road Binder solids is organic biodegradable components, including carboxylates, mono-and polysaccharides. These compounds are represented by the carbonaceous biochemical oxygen demand (BOD_5) concentration of 115,000 mg/L measured in the study sample.

Extensive studies on the major degradation paths of Road Binder components (except phenols) have not been carried out (Domtar, November, 1987). Solubilized organic compounds carried to surface waters will exert an oxygen demand, this reducing the dissolved oxygen levels necessary for aquatic life. Based on the results of studies on phenols, discussed below, biodegradation of many organics will occur very shortly after application.

Lignin

Lignin itself is very stable in the biosphere, and very few biological agents can degrade the lignin molecule (School of Public Health, 1982). They have low penetrability through soils and therefore, are little threat to groundwater aquifers.

In surface waters, larger lignin particles deposit at benthic areas or in the sediment, while finer particles can be carried long distances. One study found that 41 to 46 percent of added lignin remained in a river after 20 weeks (Kroner and Moore, 1953).

Suspended Matter

The suspended matter component of Road Binder is primarily wood and bark fragments. These would cause no significant environmental impact.

Phenolics

The majority of phenols released to land will be rapidly biodegraded by soil microbial populations in approximately 2 to 5 days. This process will occur even in the subsurface soils, although it will be much slower under anaerobic conditions than under aerobic conditions. Contamination of ground water is unlikely due to this rapid biodegradation, despite the high water solubility of phenol. Some phenols will be lost to evaporation and once in the atmosphere, it may photodegrade directly, or react with photolytically produced hydroxyl radicals or nitrate radicals (Howard, 1989).

Phenol has some natural sources including animal wastes and decomposition of organic materials. However, it is also a widely used industrial chemical and occurs in auto exhaust, cigarette smoke as well as disinfectants and medicinal products. Concentrations in surface waters are generally less than 5 µg/l (Howard, 1989).

The environmental impacts of phenols present in Road Binder have been studied in detail by Domtar. The concentrations of phenolic compounds in Road Binder were presented in Table 3.

In one study, a sample of road surface soil was collected before Road Binder application, just after application (at a rate of 1 L/m^2) and 24 hours after application. There was no rainfall during the 24 hour test, period. Each sample was analyzed for total phenolics and the range of phenolic compounds, as well as sodium. The results showed that total phenolics concentration in the road soils decreased by a factor of 2.5 in the first 24 hours, and the phenol concentrations by a factor of 5. The sodium concentration remained constant over the 24 hour period, indicating that there was no migration of the Road Binder (since sodium is the most mobile component) (Domtar, November, 1987).

A second study for Domtar (Acres, 1990) investigated the potential for accumulation and infiltration of phenolic compounds in roadside ditches following the spraying of Road Binder if it was improperly applied, or applied just before a rainfall event. Infiltration was measured at two test sites near Trenton, Ontario, one representing sandy soil and the second, silty clay. The Road Binder was applied twice each year in 1988 and 1989 at rates four times greater than normal. Piezometers and lysimeters were installed at each site to test groundwater and vadose water. The experiment was designed to detect changes in the pH, conductivity, concentrations of phenolic compounds, colour and sodium content. Soil analyses results indicated that most of the phenolics and sodium remained on the surface crust at both the sandy and clay sites. Infiltration of phenolics was approximately 0.5 m at the silty clay site, and up to 1 m at the sandy site.

A second experiment was reported in the Acres report. Soil columns from the test site were injected in the laboratory with Road Binder, followed by 43 cm of water (simulating abnormally high rainfall and a worse case scenario for phenolics infiltration. Study results found 98 percent of the total phenolics was retained, and decayed, within the first 0.5 m (silty clay) and 0.6 m (sandy). Removal of phenolics from Road Binder in soil was attributed to adsorption on clay or organic matter, and natural bacterial activity. The latter is one of the most important factors in long term removal of phenols from the soil.

CONTAMINANT BASED ASSESSMENT

The following discussions focus on the environmental impacts of the various contaminants identified in Road Binder, including:

- Metals
- Ammonia

- Phosphorus
- Dioxins

Metals

None of the metals concentrations on the sample analyzed for this study exceeded the soil background or clean-up levels. A study of metals levels in road materials, ditch materials and vegetation at a road Southern Ontario treated with Road Binder indicated that levels did not appear to increase by the application of Road Binder for dust suppression (Acres, 1988). The results indicate that Road Binder did not increase soil metal levels under normal use. However, long term effects of metal build-up in treated soils and surrounding areas have not been measured.

Ammonia Nitrogen

The Domtar Road Binder sample tested for this study contained 177 mg/L of ammonia nitrogen.

Ammonia released to land will evaporate rapidly in the initial stages. Once in the air, ammonia may be subject to some oxidation and may thus contribute to acid rain. In addition, it combines with sulphate and returns to the soil via rainfall washout. Its residence time in the air is short (5 to 10 days). However, since it is essentially miscible with water, some of it will penetrate into the soil. Adsorption to soil particles does occur, especially onto clay minerals, but this adsorption is reversible and subsequent leaching of the ammonia will occur. This reversible adsorption provides some retardation of the ammonia transport rate in groundwater. Biodegradation in soil also occurs and the resulting nitrate is more highly mobile in the soil. Under anaerobic conditions in water, ammonia will accumulate, but oxidize to nitrate and nitrite under aerobic conditions.

Phosphorus

A total concentration of phosphorus of 170 mg/L in Road Binder was measured in the study sample. Phosphorus released to land will rapidly runoff under saturated soil conditions. Downward movement will occur when soil is not completely saturated. In the soil, adsorption to soil particles is possible but not a dominant fate mechanism. Most phosphates penetrating the soil will be carried with the groundwater. Phosphates are indefinitely persistent in both surface and groundwater. They are nutrients for aquatic life and can stimulate increased growth of algae. Excess amounts contribute to long term eutrophication. Phosphates will not enter the atmosphere from a release to land.

Dioxins

Low levels of dioxins (0.03 ng TEQ/L) were present in the sample of Road Binder tested for this study. The levels present in the sample was four orders of magnitude lower than the soil assessment criterion for contaminated sites, of 1,000 ng TEQ/kg.

Summary

The following points summarize the environmental impacts associated with applying Road Binder to roads for dust suppression and road stabilization:

- Domtar reports that most components of Road Binder applied to road surfaces will form an impervious crust, and very few soluble components will leach away.

- Sodium is the most mobile component of Road Binder in the environment. The quantity of sodium applied through Road Binder applications for dust suppression is two orders of magnitude lower than the quantity applied for winter road deicing using sodium salts.

- Studies have not examined the major degradation paths of Road Binder components. Solubilized organic components entering waterways would reduce dissolved oxygen levels.

- Lignin present in Road Binder is very stable in the biosphere and not easily biodegraded.

- The average concentration of a range of phenolic compounds in Road Binder was reported to decrease by a factor of 2.5 in the 24 hours after road application when no rainfall occurred. Under abnormally high application rates and rainfall conditions, Road Binder phenolics infiltrated in sandy soils to 1 m and in clay soils, to 0.5 m. Phenols are decreased in soils through adsorption and bacterial decay.

- Ammonia applied to land with Road Binder applications will evaporate, solubilize in passing runoff and biodegrade in the environment. It may also be used as a nutrient for vegetation.

- Phosphorus released to land will rapidly runoff under saturated soil conditions. Phosphates are indefinitely persistent in the environment.

- Metals present in Road Binder do not appear to affect background levels in road materials and surrounding areas.

- Dioxins in Road Binder are present at levels 4 orders of magnitude less than soil assessment criteria for contaminated sites.

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT AND PREPARATION INFORMATION

EMERGENCY: 514 - 331 - 6100
CANUTEC : 613 - 996 - 6666

Trade Name: DOMTAR ROAD BINDER

Synonym: SPENT PULPING LIQUOR (SODIUM CARBONATE BASE)
Product Code: PACKCO 0005
Chemical Name and Synonym:

Manufacturer

DOMTAR PACKAGING
CONTAINERBOARD DIVISION
TRENTON MILL
TRENTON, ONTARIO

Supplier

Preparation Date: October 21, 1988

Name of Department Preparing MSDS
DIVISION HEAD OFFICE
MALTON, ONTARIO
Information Tel. #: (416) 671 7409
Signature of Preparer:
DR. R.S. ALLAN

Chemical Family: N/AP
Formula: N/AV
TDG Shipping Name: N/AP
TDG Hazard Class: N/AP
WHMIS Class: N/AP

Hazard Rating

Health: 1 Flammability: 0
Reactivity: 1

NOT CLASSED AS HAZARDOUS

Product Use:

ROAD BINDER/DUST SUPPRESSANT
THE PRODUCT DESCRIBED HERE IS A SOLUTION OF SHORT-CHAIN CARBOXYLATES, POLYSACCHARIDES, LIGNIN AND LIGNIN-BREAKDOWN PRODUCTS, SODIUM CARBONATE WITH SOME SUSPENDED SOLIDS (WOOD & BARK FRAGMENTS).

SECTION II - HAZARDOUS INGREDIENTS

CHEMICAL IDENTITY	CAS NUMBER	PER CENT BY WEIGHT
NO HAZARDOUS INGREDIENTS ABOVE 0.1% LEVEL.		

SECTION III - PHYSICAL DATA

Physical State (room temperature)	LIQUID, 10-35% TOTAL SOLIDS (USUALLY 20-
Odour and Appearance	FAINT, WOODY ODOUR; BROWN/BLACK COLOUR
Odour Threshold	NOT AVAILABLE
Boiling Point	APPROXIMATELY 100°C
Freezing Point	APPROXIMATELY 0°C
Percent Volatile by Volume	65-90%
Specific Gravity	APPROXIMATELY 1.1
Evaporation Rate (butyl acetate = 1)	NOT AVAILABLE
Vapour Pressure	SAME AS WATER
Vapour Density (air = 1)	NOT AVAILABLE
pH	8.6 -- 8.7
Coefficient of water/oil distribution	NOT AVAILABLE
Solubility in water	NOT APPLICABLE

SECTION IV - FIRE OR EXPLOSION HAZARDS

Conditions of Flamability	NON-FLAMMABLE
Extinguishing Media	NOT APPLICABLE
Hazardous Combustion Products	NOT APPLICABLE
Special Fire Fighting Procedures	NOT APPLICABLE
Flash Point & Method of Determination	NOT APPLICABLE
Upper Flammable Limit	NOT APPLICABLE
Lower Flammable Limit	NOT APPLICABLE
Auto-ignition Temperature	NOT APPLICABLE

Explosion Data
Sensitivity to mechanical impact N/AP : Sensitivity to static discharge N/AP :

SECTION V - REACTIVITY DATA

Stability	STABLE
Conditions to Avoid	LONG TERM STORAGE IN CLOSED CONTAINERS SHOULD BE AVOIDED.
Incompatible Substances	CONTACT WITH STRONG ACID COULD LEAD TO FOAM GENERATION
Hazardous Decomposition Products	NOT APPLICABLE
Hazardous Polymerization	WILL NOT OCCUR

SECTION VI - TOXICOLOGICAL PROPERTIES

Route of Entry : Skin contact X Skin absorption _____ Eye contact X
Inhalation _____ Ingestion _____

Effects of Acute Exposure ..: INFORMATION NOT AVAILABLE

Effects of Chronic Exposure : INFORMATION NOT AVAILABLE

EXPOSURE LIMITS

CHEMICAL COMPONENT	_____ TWA	ACGIH TLV	LC50	LD50	IDLH
NOT AVAILABLE					

IDLH: immediately dangerous to life/health

Irritancy .....: NOT AVAILABLE

Sensitization .....: NOT AVAILABLE

Carcinogenicity.....: NOT AVAILABLE

Reproductive Toxicity: NOT AVAILABLE

Teratogenicity .....: NOT AVAILABLE

Mutagenicity .....: NOT AVAILABLE

Toxicologically Synergistic Products: NOT AVAILABLE

SECTION VII - PREVENTIVE MEASURES

Hand Protection.....: GLOVES IMPERVIOUS TO AQUEOUS MIXTURES
Eye Protection.....: SAFETY GLASSES OR GOGGLES ADVISED
Respiratory Protection.: NOT APPLICABLE
Body Protection.....: NOT APPLICABLE
Foot Protection.....: NOT APPLICABLE
Ventilation Controls...: NOT NORMALLY REQUIRED

Steps to be taken in case of a leak or spill:

MOP UP OR HOSE DOWN

Waste disposal method:

CLASSED AS AN INDUSTRIAL WASTE IN ITS PRESENT USE -- CUSTOMARY PROCEDURES FOR NON-HAZARDOUS INDUSTRIAL WASTE TREATMENT.

Precautions to be taken in handling and storing:

STORE IN OPEN CONTAINERS AND/OR VENTILATE WELL. USE CAUTION WHEN OPENING UNVENTED CONTAINERS. MICROBIAL ACTIVITY MAY CAUSE ACCUMULATION OF COMBUSTIBLE GAS.

Special shipping requirements:

NONE

SECTION VIII - FIRST AID MEASURES

Skin Contact.....: WASH AFFECTED AREA COPIOUSLY WITH WATER

Eye Contact.....: RINSE WITH RUNNING WATER FOR AT LEAST 15 MINUTES

Inhalation.....: NOT APPLICABLE

Ingestion.....: NOT APPLICABLE

Disclaimer: DOMTAR BELIEVES THE ABOVE INFORMATION IS RELIABLE. HANDLING OF THE DESIGNATED PRODUCT SHALL BE RESTRICTED TO QUALIFIED PERSONS. DOMTAR MAKES NO WARRANTY, EXPRESSED OR IMPLIED, WITH RESPECT TO SUCH INFORMATION AND ASSUMES NO RESPONSIBILITY WHATSOEVER FOR ANY DAMAGE WHICH RESULTS FROM THE USE OF SUCH INFORMATION OR THE DESIGNATED PRODUCT. USERS MUST MAKE THEIR OWN TESTS WHEN USING THE DESIGNATED PRODUCT WITH ANY OTHER PRODUCT OR ANY PROCESS.

APPENDIX E.5

DCS-225

REVIEW PARAMETER LIST FOR DCS-225

A. GENERAL INFORMATION

DCS-225 distributed in Ontario by NorJohn Ltd., is a dark brown liquid with a sulphurous odour. It is a blend of tall oil, asphalt, and water, which falls into the general category of an emulsified asphalt resin, and is in the chemical family of petroleum hydrocarbons. DCS-225 is used as a road dust suppressant, a stock pile dust suppressant for coal and flash, as well as for road shoulder spraying. Generally, the concentrated liquid is diluted with water in a 3 to 1, water to product mix, for road application.

SUPPLIER/DISTRIBUTOR INFORMATION

Manufacturer

NorJohn Ltd.
P.O. Box 100
Thorold, Ontario
L2V 3Y8

Telephone: (416) 356-7222
Contact: Dave Bratley

NorJohn, who blends DCS-225 is also the supplier.

Applicators/Contractors

Dave Bratley of NorJohn (416) 356-7222 should be contacted to provide information on applicators of DCS-225 in Ontario. NorJohn also provides application services.

COST INFORMATION

The cost of concentrated DCS-225 purchased from NorJohn is approximately $0.26/L (1991).

Transportation cost are generally included in the contractors application cost. Final costs of applied DCS-225 are about $0.17 per litre of diluted product (3 to one, water to product). At a typical application rate of 1.8 L/m^2 and two applications per season, this results in a 1991 cost of $0.61 per square meter per season.

SAFETY PROCEDURES

The following safety procedures are recommended for the handling of DCS-225.

Personal Protection

1. Operators should avoid any eye or skin contact.

2. Operators should wear gloves with gauntlets. Gloves should not be made of natural rubber or PCV.

3. Operators should wear either splash proof chemical goggles or an 8" face shield if splashing or eye contact is possible.

4. Operators are not required to wear respirators under normal operating conditions.

5. Operators should wear approved air purifying respirators for dust/fumes/mist and organic vapours, or wear supplied air respirator if in enclosed areas.

6. Operators should wear long sleeve loose fitting clothing, closed at the neck and tight at the waist.

7. Operators should wear impervious safety boots.

Emergency First Aid

First aid procedures are outlined in the attached Material Safety Data Sheet (1990) for DCS-225.

Storage Requirements

DCS-225 should be stored in closed containers and should be kept away from all oxidizing materials and sources of ignition. The product should be kept from freezing, since this will break the emulsion, and possibly the container, as a result of the water content.

Transportation Requirements

The concentrated product is shipped at slightly elevated temperatures to aid in pumping at the discharge site. Diluted DCS-225 is not elevated in temperature during

shipping or pumping. All other precautions necessary in the transportation of industrial hydrocarbon liquids should be exercised.

Spill Procedures

In accordance with Part 9, Section 79 of the Environment Protection Act, a spill is defined as any discharge, intentional or unintentional, of material from its containing unit beyond the recommended maximum application rate, into the natural environment. This can be caused by spray bars left on after operation, tank rupture, tank over turn, etc. In the event of a spill the following procedures are recommended:

1. The spill should be contained using sand or earth to prevent DCS-225 from entering waterways or low areas. All sources of ignition must be removed.

2. As much of the DCS-225 should be recovered with pumping equipment or absorbent material.

3. The remaining spilled DCS-225 should be absorbed with sand or clay.

4. The following should be contacted:

    - The local municipal authorities.
    - The Ontario Ministry of the Environment Spills Action Centre at 1-800-268-6060.
    - Environment Canada at The Ontario Regional Environmental Emergencies line: (416)-973-1059, or (416)-346-1971 (cellular).
    - Norjohn Ltd.
    - The applicator.

SOURCE DESCRIPTION AND QUALITY CONTROL

DCS-225, a blend of tall oil, asphalt and water, is made up by NorJohn. The tall-oil is supplied by E.B. Eddy Forest Products Ltd., and the asphalt is supplied by Petro Canada. The raw materials are delivered to specifications prescribed by NorJohn, and tested on-site to ensure delivered product is within specifications. The tall oil and asphalt are mixed together first. After which, the water and 0.5 percent caustic is added to the mixture as it enters a mill which mechanically disperses the mixture. The resulting mixture forms a 60 percent solids emulsion which is later diluted to 3 parts water, 1 part DCS-225 for road application.

Every batch of DCS-225 blended is tested for dilution, percent residue, and percent settlement. Testing occurs every few days, whether or not a new batch is produced or not.

B. TECHNICAL EFFECTIVENESS AND APPLICATION PROCEDURES

TECHNICAL EFFECTIVENESS

DCS-225 is designed for, and is primarily used as, a dust suppressant. It functions primarily by penetrating the surface, coating the road particles, and crusting the top layer similar to lignosulphonates. As a result, fines tend to bind together which prevents them from becoming airborne.

Emulsified asphalt resins have been used as dust suppressants for many years in North America under a variety of circumstances and conditions. To investigate the overall technical effectiveness of DCS-225 a telephone survey of current and past users in Ontario was conducted by CH2M HILL as part of the present study. No literature reports have been found that specifically evaluate DCS-225. Therefore, a general discussion on the effectiveness of emulsified asphalt resin products, is also presented in this section to supplement the available information on DCS-225. To this end, literature on Petro Tac, an emulsified resin product used in the U.S., has been reviewed.

As with all dust suppressants, the dust controlling ability and longevity of DCS-225 is dependent on road maintenance, weather conditions, traffic loads, and soil composition.

Users in Ontario surveyed were generally not as satisfied with the performance of DCS-225 for municipal road dust suppression compared to other dust suppressants, since its effectiveness lasted only 3 to 10 weeks compared to longer periods for other dust suppressants. In addition, the road surfaces treated with DCS-225 were subject to potholing and rapid deterioration. Maintenance of the road, however, can destroy the surface crust and render the DCS-225 application ineffective in controlling dust.

An effective period of about 4 weeks was observed in a Northern Saskatchewan field study (Saskatchewan, 1972), which evaluated the effects of grading on the effectiveness of various chemicals as dust suppressants and road stabilizers. The study indicated that overall, the emulsified asphalt resin provided good dust suppression, but treated roads were subject to rapid pitting. It was recommended that the emulsified asphalt resin be reapplied half way through the season to maintain effectiveness. Maintenance blading was possible for the treated road surface but the redistributed aggregate did not bind to the surface.

In the CH2M HILL telephone survey, users indicated that rain showers within twelve hours of the application of DCS-225 shortens the length of the effective period of dust control.

A field test carried out by PEDCO (1983) tested surface coal mine haul roads at three mines to determine the effectiveness of dust controls used on unpaved mine haul roads. The study noted that roads with very high silt contents treated with an emulsified asphalt resin (Petro Tac) became slippery and very muddy and rutted, during wet weather.

It was also reported, however, in a study on the long term effectiveness of various dust suppressants used on roads in the iron and steel industry (The Midwest Research Institute, 1984) that damp weather can aid in dust suppression. The Midwest Research Institute compared Petro Tac (an emulsified asphalt resin), water, and Coherex (an emulsified petroleum resin) at two plant sites. Isokinetic profiling was used to measure controlled and uncontrolled dust emissions. The site treated with Coherex received 6.6 cm of rain over the 4 month test period, while the Petro Tac site received 38.8 cm of rain over the 4 month test period. Much of Petro Tac's superior dust suppression over Coherex's was attributed to the wetter weather. In one study (PEDCO, 1983), roads that had silt contents of less than 10 percent were not as slippery during wet weather.

The influence of traffic load was also seen in the iron and steel industry study (The Midwest Research Institute, 1984). Petro Tac remained effective as a dust suppressant for 100,000 vehicle passes (where effectiveness is defined as at least 50 percent of the initial dust suppression efficiency). On the other hand, Coherex was effective for only 7,500 vehicles. Petro Tac's longer lifetime was partly due to the lower average vehicle weight of 27 tonnes versus 34 tonnes for Coherex. In a PEDCO mine road study (1983) under traffic volumes of 8 to 900 vehicle passes per day, and similar vehicle weights (no average number reported), Petro Tac had half of the dust suppressing control compared to all the other chemicals tested, especially lignosulphonates and calcium chloride, which function in a similar manner of binding and crusting the surface. In a Saskatchewan Department of Highways field study (1972), emulsified asphalt resin used on municipal roads with an average municipal daily traffic volume of 250, pitted and potholed after 6 weeks.

The fines content in surface materials also affects the dust controlling ability of oil asphalt emulsions. In The Midwest Research Institute iron and steel industry roads study (1984), Petro Tac was found to be effective for control of total fines particles (less than 75μm) for up to 100,000 vehicle passes. However, for particles less than 2.5μm in diameter, Petro Tac was effective for only 50,000 vehicle passes. In a subsequent study by The Midwest Research Institute (1987) within the same industry, it was found that Petro Tac's ability to control silt from becoming airborne, was dependent on the silt diameter. However, no clear relationship between control versus particle diameter could be derived from these studies.

Summary of Overall Effectiveness

The technical effectiveness of emulsified asphalt resins is a function of several factors, summarized below:

1. Maintenance grading appears to be required when DCS-225 is applied to roads because it promotes potholing and pitting. However, grading reduces the dust suppressing effectiveness of DCS-225.

2. Application of DCS-225 without sufficient curing time before a rainfall may result in severe potholing and rutting of the road.

3. Humidity and rain can aid in dust suppression when an emulsified resin is applied, but may render the roads very slippery.

4. The effective lifetime of an emulsified asphalt resin is inversely proportional to the weight and density of vehicular traffic on the treated road.

5. The effectiveness of emulsified asphalt resins varies with the size of the silt particles present in the roads treated, but with no clear relationship to particle diameter.

APPLICATION PROCEDURES

Site Restrictions

According to the Ontario Ministry of Environment's Draft Guidelines for the Application of Dust Suppressants, dust suppressants should not be applied to sites closely adjacent to or crossing waterway(s) or marshes, or near wells.

Surface Preparation

Published information for the preparation of road surfaces prior to DCS-225 application was not identified in the information search. Information is based on the telephone survey conducted with current users and NorJohn. Preparation should be as follows:

1. Proper drainage should be provided on both sides of the road.

2. The surface should be graded to a significant depth (20 to 50 mm) to remove pot holes, corrugations and other ruts. If the road is deeply rutted or corrugated it may require scarification up to 100 mm.

3. Gravel or fines should be added as required to yield a final composition of 10 to 15 percent fines (< 200 mesh) (UMA Engineering Ltd., 1987).

4. The road should be shaped to the correct crown (about 4% straight line) using a grader equipped with a straight flat blade.

5. The DCS-225 should be applied at desired levels while the surface is still a little moist.

6. If the road on surface is being constructed, compaction of the surface is suggested to provide a firm solid base.

Length of Time Before and After Precipitation

Current and past users of DCS-225 have recommended that if heavy rainfall is forecast within 24 hours, application of DCS-225 should be postponed until after such rainfall to avoid leaching and runoff. DCS-225 should be applied while the road has some moisture remaining, within 12 to 24 hours after a significant rainfall.

Application Equipment

Application equipment for petroleum based products and oils is usually a bituminous distributor. The Ontario Ministry of Transportation requires that the distributor be equipped with a pump capable of developing a constant uniform pressure in the spray bar manifold. In addition, the spray bar must be capable of application over a variety of widths. The distributor tank should also come equipped with a dip stick for measuring quantities applied.

The equipment list for bituminous distributors also contains the following:

- Recirculation in the tank.
- A quick opening gate in the dome.
- An external readily visible tank gauge.
- Rear mounted spray bars and nozzles 0.6 to 3.6 m wide capable of:
  - vertical and lateral adjustment
  - producing double coverage in one pass.
- Spray bars that do not extend into the lane of opposing traffic unless adequate warning measures are taken.

- The feed to the spray bars equipped with:
  - recirculation before and during operation
  - filters.

- Spray nozzles:
  - fitted with instant on/off valves, and
  - which yield fan-shaped sprays without atomization.

- A pressure pump capable of supplying approximately 726 L/min of product.

- An operator visible 345 MPa pressure gauge.

- An operator visible flow meter.

- An operator visible pump tachometer.

Personnel Requirements

Typically two to four people are required for safe application of dust suppressants. This would consist of at least one, maybe two, flag-persons and/or an operator of a warning pilot vehicle, the operator of the application truck, and an application checker (the flag person can double as a checker)

Dilution

DCS-225 is to be mixed with three parts water to one part product for optimum performance. DCS-225 should not be mixed with any other materials, especially any strong oxidizing agents.

Application Rate and Frequency

NorJohn has recommended that diluted DCS-225 be applied in two equal coats at 0.9 L/m^2 each for a total of 1.8 L/m^2. This procedure would facilitate pre-wetting of the surface particles for the second application. Subsequent applications are at the same rate. Usual municipal application of DCS-225 is twice per year.

Ponding should be avoided during application. Ponding will depend on several factors; the rate of dust suppressant discharge, the speed of the application truck, and the porosity of the surface materials. Ponding can be prevented by shutting off the spray bars when the vehicle/truck is stopped or is passing over paved/sealed portions of the road. Care should be taken to ensure that the liquid is applied at or below the

suggested rates. If ponding still occurs, then a decrease in the application rate is necessary.

Curing

The curing time for DCS-225 is between two and four hours, depending on the weather, to permit the tall oil to cross link and crust over. Traffic should be restricted to slower speeds for this period of time.

Problem and Hazards

Roads treated with DCS-225 may be more slippery during wet weather than untreated roads.

C. PHYSICAL AND CHEMICAL CHARACTERISTICS

PHYSICAL PROPERTIES

The physical characteristics of DCS-225 are presented in Table 1.

Table 1
Physical Properties of DCS-225

Property	
Odour	Sulphurous odour
Appearance and colour before application	Dark brown liquid
Physical state when applied	Viscous liquid
Physical state when dried	Solid, crusty
pH	6 to 8
Solubility in water	Complete
Boiling point	100 °C
Freezing point	0 °C

Source: DCS-225 Material Safety Data Sheet from NorJohn Ltd (1990).

Chemical Properties

The main components of undiluted DCS-225 are (MSDS, 1990):

- Water (80 to 90%)
- Bitumens (0.5 to 1.5 %)
- Proprietary blend of fatty acids (8.6 to 19.5%)

One undiluted sample of DCS-225 was provided by NorJohn for the study. The sample was diluted to the recommended 3 to 1, water to product ratio, and the diluted sample was split for duplicate analyses. Analyses for conventional parameters, metals, volatile organic compounds (VOCs) and polynuclear organic hydrocarbons (PAHs) were carried out by CANVIRO Analytical Laboratories Ltd. The averaged results of duplicate analyses of DCS-225 are presented in Table 2.

The sample contained approximately 6 percent extractable oil and grease, and a significant biodegradable component, evidenced by a BOD_5 concentration of 23,000 mg/L. Phosphorus levels were also significant, at 152 mg/L. Only low levels of aluminum boron, iron, copper, strontium, zinc, and mercury were detected in the metals analysis. Lighter PAH compounds, plus benzo (a) pyrene, were present at levels up to 286.5 µg/L. Five VOCs were detected, including methylene chloride, toluene, m&p-xylenes and o-xylene, and ethylbenzene, at concentrations up to 1,710 µg/L.

D. ACUTE TOXICITY AND SUB-LETHAL EFFECTS

ACUTE TOXICITY

B.A.R. Environmental conducted acute toxicity tests using the same sample of DCS-225 provided for chemical analyses, which was diluted (3 to 1) in the laboratory using tap water for duplicate toxicity testing on rainbow trout and Daphnia magna. The test measured the LC50 values and their corresponding 95 percent confidence interval. The LC50 is the median lethal concentration (i.e. the concentration of the test chemical in water that is estimated to be lethal to 50 percent of the test organisms within a prescribed period of time). Test results are presented in Table 3.

Diluted DCS-225 is lethal to rainbow trout at a concentrations of 191 mg/L, and to Daphnia magna at a concentration of 521 mg/L. According to one rating system (IMCO/FAO/UNESCO/WMO, 1969), Dust Bond rates a grade 2, on a scale of 0 to 4 where 0 is least toxic.

SUB-LETHAL EFFECTS

To assess the potential sub-lethal effects of DCS-225, each individual chemical component present at concentrations above guidelines and standards for drinking water and/or aquatic life, as presented in Table 4, was examined.

Table 2
Chemical Characteristics DCS-225[1]

	Units	Concentration
Conventional Parameters		
pH	mg/L	8.6
Total solids	mg/L	59500
BOD_5	mg/L	23000
Ammonia Nitrogen	mg/L	<20
Total Phosphorus	mg/L	153
Oil & Grease	mg/L	60600
Metals		
Aluminum	mg/L	0.05
Boron	mg/L	0.06
Barium	mg/L	<0.01
Beryllium	mg/L	<0.005
Cadmium	mg/L	<0.012
Calcium	mg/L	5.35
Chromium	mg/L	<0.02
Cobalt	mg/L	<0.03
Copper	mg/L	0.04
Iron	mg/L	0.615
Lead	mg/L	<0.1
Magnesium	mg/L	1
Manganese	mg/L	<0.01
Vanadium	mg/L	<0.01
Zinc	mg/L	0.01
Nickel	mg/L	<0.02
Silver	mg/L	<0.02
Strontium	mg/L	0.025
Sodium	mg/L	243
Arsenic	mg/L	<0.05
Selenium	mg/L	<0.01
Mercury	mg/L	<0.001
Polynuclear Aromatic Hydrocarbons		
Naphthalene	µg/L	682
Acenaphthylene	µg/L	<3.2
Acenaphthene	µg/L	61.3
Fluorene	µg/L	134.5
Phenanthrene	µg/L	286.5
Anthracene	µg/L	<6.4
Fluoranthene	µg/L	<4.8
Pyrene	µg/L	<3.2
Benzo (a) anthracene	µg/L	<4
Chrysene	µg/L	<5.6
Benzo (b) fluoranthene	µg/L	<5.6
Benzo (k) fluoranthene	µg/L	<5.6
Benzo (a) pyrene	µg/L	55.15
Indeno (1,2,3-cd) pyrene	µg/L	<8.8
Dibenzo (a,h) anthracene	µg/L	<6.4
Benzo (ghi) perylene	µg/L	<7.2

Table 2
Chemical Characteristics DCS-225[1]

	Units	Concentration
Volatile Organic Compounds		
Chloromethane	µg/L	<180
Vinyl Chloride	µg/L	<250
Bromomethane	µg/L	<100
Chloroethane	µg/L	<80
Trichlorofluoromethane	µg/L	<175
Acrolein	µg/L	<110
1,1-Dichloroethylene	µg/L	<80
Methylene Chloride	µg/L	1710
Acrylonitrile	µg/L	<105
Trans - 1,2-dichloroethylene	µg/L	<35
1,1-Dichloroethane	µg/L	<25
Methyl ethyl ketone	µg/L	<55
Chloroform	µg/L	<20
Bromochloromethane	µg/L	<10
1,1,1,-Trichloroethane	µg/L	<25
Carbon Tetrachloride	µg/L	<35
1,2-Dichloroethane	µg/L	<15
Benzene	µg/L	<20
Trichloroethylene	µg/L	<95
1,2-Dichloropropene	µg/L	<10
Bromodichloromethane	µg/L	<10
2-Chloroethylvinyl ether	µg/L	<20
Trans-1,3-Dichloropropylene	µg/L	<15
cis-1,3-Dichloropropylene	µg/L	<25
Toluene	µg/L	390
1,1,2-Trichloroethane	µg/L	<15
Tetrachloroethylene	µg/L	<40
Dibromochloromethane	µg/L	<10
Ethylene dibromide	µg/L	<30
Chlorobenzene	µg/L	<10
m&p Xylene	µg/L	1003
Ethylbenzene	µg/L	265
Styrene	µg/L	<20
o-Xylene	µg/L	513
Bromoform	µg/L	<15
1,1,2,2,-Tetrachloroethane	µg/L	<25
1,3-Dichlorobenzene	µg/L	<10
1,4-Dichlorobenzene	µg/L	<5
1,2-Dichlorobenzene	µg/L	<20

Notes:

1 Average of duplicate sample analyses of DCS-225 diluted with water (3 parts water to 1 part DCS-225).
< Below detection limit.

Comparing the concentrations of toxic substances in 100 percent strength of the dust suppressant product provides an indication of toxicity to human and aquatic life only on a"worst case" basis. Some dilution effects will occur once the material is released to land and exposed to the effects of runoff, leaching and degradation. In addition, concentration of persistent substances after repeated application may also occur. The

exact extent of dilution or build-up will depend largely on site specific factors and will not be addressed in generic assessments of sub-lethal effects.

Table 3
Acute Toxicity to Rainbow Trout and Daphnia Magna

Organism	Effect	DCS-225	
		Concentration (mg/L)	95% Confidence Interval
Rainbow Trout	LC50 (96h)	191	166 - 218
Daphnia magna	LC50 (48h)	521	415 - 727

Table 4
Comparison of Contaminant Limits for Drinking Water and Aquatic Life to Concentrations in DSC-225[1]

Parameter	Aquatic Life	Drinking Water	DCS-225
Phosphorus (mg/L)	0.02 (algal growth)[2]	n/a	153
Iron (µg/L)	300[2]	300[2]	615
Naphthalene (µg/L)	n/a	n/a	682
Acenaphthene (µg/L)	n/a	n/a	61.3
Fluorene (µg/L)	n/a	n/a	134.5
Phenanthrene (µg/L)	n/a	n/a	286.5
Benzo (a) pyrene (µg/L)	n/a	0.2[5,6]	55.2
Methylene chloride	98[4]	1,750[7]	1,710
Toluene (µg/L)	300[4]	24[3]	390
m & p-xylenes (µg/L)	n/a	30[3]	1,003
Ethylbenzene (µg/L)	700[4]	2.4[3]	265
o-Xylenes (µg/L)	n/a	30[3]	513

Notes:

1. Only parameters with concentrations exceeding referenced limits are presented.
2. Ontario Ministry of the Environment, 1984. Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.
3. Health and Welfare Canada, 1987. Canadian Guidelines for Drinking Water Quality.
4. Environment Canada and Health and Welfare Canada, 1991. How Safe is Our Water?
5. World Health Organization, 1984. Guidelines for Drinking Water Quality. Volume 2 Health Criteria and other supporting information.
6. Total for 6 PAH compounds.
7. E.P.A Cited from W.H.O. Literature.

In the absence of a detailed exposure and risk assessment, it is not possible to completely assess the degree of human or environmental health risk posed by DCS-225. The following discussion attempts only to identify the contaminants of concern which could potentially cause problems over the long term. In many cases, the toxological data available is limited.

Main Components

DCS-225 is not significantly absorbed through skin. Prolonged contact may cause irritation and/or dermatitis. DCS-225 can cause irritation, inflammation, blistering, drying and scaling by defatting the skin (DCS MSDS, 1990).

DCS-225 may causes eye irritation on contact, swelling of eye tissues (conjunctivitis) and corneal burns, moderate irritation the respiratory tract if inhaled, and affect the central nervous system. It may also irritate the gastrointestinal tract and skin. The primary routes of entry into human bodies are via skin contact, inhalation and ingestion.

Contaminant Based Assessment

PAH compounds found in DCS-225 have been shown to have teratogenic, mutanogeic and/or carcinogenic properties in animals, and are probably human carcinogens. In addition, PAHs may be bioconcentrated in fresh waste invertebrates. However, the heavier PAH compounds, such as benzo (a) pyrene, which are those of most concern, are likely to remain closely associates with roadbed materials, and not very mobile. Therefore, contamination of drinking water, groundwater or surface water is unlikely. Injestion or inhalation of road dust, or mist during application, may be more likely routes of exposure. There are many natural and anthropogenic sources of PAH.

Volatile organic compounds such as toluene and xylenes found in DCS-225 reportedly have toxic and sub-lethal effects. However, given that these compounds will be rapidly lost to the atmosphere via evaporation after application, and that DCS-225 would only be used once or twice per season, contamination of ground or surface water and aquatic or drinking water toxicity effects are unlikely. VOCs may be a concern to applicators, or in the case of industrial site application, where there is worker exposure.

Guidelines for iron are based on aesthetic considerations, and are significantly lower than those of concern to human health. Toxic effects resulting from the iron content in DCS-225 are not likely.

The carbonaceous (BOD_5) oxygen demand of DCS-225 would reduce dissolved oxygen in surface waters. Oxygen concentrations of 4 to 8 mg/L (depending on temperature) are necessary for freshwater aquatic life (MOE, 1984). Phosphorus in surface waters may promote noxious algae growth. Effects of these components should not be a concern under normal dust suppressant use, and as long as care is taken not to apply the material in the vicinity of surface water.

SUMMARY

The following points summarize the acute toxicity and sub-lethal assessment of DCS-225:

- Acute toxicity tests showed diluted DCS-225 to be lethal at concentrations of 191 mg/L to rainbow trout, and 521 mg/L to Daphnia magna.

- Information on the sub-lethal effects of DCS-225 was limited. It may absorb dermally with contact resulting in irritation or dermatitis. In addition, contact with eyes will result in eye irritation, swelling, corneal burns. Inhalation may affect the central nervous system.

- PAH compounds present in DCS-225 would not likely contaminate water supplies. However, exposure may occur through inhalation of mist during application or road dust.

- The levels of metals present in DCS-225 are low and not likely to have significant toxic or sub-lethal effects.

D. ENVIRONMENTAL IMPACTS

MAIN COMPONENTS

No literature sources describing field studies of the environmental impacts of DCS-225 were identified.

DCS-225 diluted for land application is less than 1 percent bitumens, 2 to 5 percent fatty acids with the remainder being water. The dust suppressing action occurs as a result of the petroleum component coating road particles to form a crust, to bind fines. The environmental behaviour of DCS-225 after application has not been documented. The bitumen crust layer would be expected to be for the most part, immiscible and have a higher viscosity than water. Therefore, migration would not be affected by water movement. It will migrate from the application site by leaching and penetrating into soil, and will be slowed by soil absorption. Some contaminants of the crust will solubilize in passing water and leach away. Lighter fractions will volatilize although the portion and rate of volatilization has not been determined. As shown by the high BOD concentration, the product has a large biodegradable component, although the overall rate of decay in the environment has not been determined. In soil, the Ontario MOE's guidelines for site clean-up recommend that oil and grease should not exceed 1 percent by weight.

COMPONENT-BASED ASSESSMENT

No studies of the use of DCS-225 which adequately describe environmental impacts were available. Examination of the individual components of the product provide the "next best" assessment of environmental fate. The analytical results of this study have

been used to develop a short list of components which represent a range of possible fates for DCS-225 released to land.

Persistence and Migration

In order to assess a range of the persistence and migration characteristics of DCS-225, a number of the components from the above list have been selected for further discussion.

For assessment of environmental impacts of PAH compounds exceeding guideline levels, presented in Table 5, two compounds were selected to represent the range of possible environmental fates for this group of compounds. Naphthalene, is the lightest PAH molecule detected, while benzo (a) pyrene (although not exceeding soil guidelines) was the heaviest PAH compound detected.

Table 5
Comparison of Contaminant Limits in Soil to Levels in DCS-225

Parameter	Soil Concentrations (µg/kg dry wt.)[2]	DCS-225 (µg/L)
Naphthalene	n/a	682
Fluorene	n/a	134.5
Phenanthrene	100	286.5
Benzo (a) pyrene	100	55.2
Methylene chloride	100	1,710
Toluene	100	390
m & p-xylenes	100 (total xylenes)	1,003
Ethylbenzene	100	265
o-Xylenes	100 (total xylenes)	513

Notes:

1. Only parameters with concentrations exceeding referenced levels are presented.
2. Canadian Council of Ministries of the Environment, 1991. Interim CCME Environmental Quality Criteria for Contaminated Sites, Final Draft. These values are interim assessment criteria and are to be considered background or recommended detection limit values.

Methylene chloride and o-xylene were selected as representative volatile organic compounds.

For organic contaminants, environmental fate and behaviour can be at least partially predicted through a knowledge of physical/chemical properties such as those presented in Table 6 for the selected organic components.

It is difficult to assess the combined effects of all the properties noted in Table 6 based solely on a review of the data. The Fugacity Level I model has been used to achieve a measure of the combined effects of these properties. It should be emphasized that this

model does not consider which environmental compartments receive releases of the chemical, nor the rate at which equilibrium is achieved. Also not taken into consideration are degradation reactions which may deplete the amount of chemical in the model environment. The results for the chemicals of interest are reported in Table 7.

Table 6
Physical/Chemical Properties of Selected Organic Components of DCS-225[1]

Component	Component Group	Molecular Weight (g/g-mole)	Vapour Pressure (mm Hg at 25 °C)	Aqueous Solubility (mg/L at 25 °C)	Log Octanol-Water Partition Coefficient	Henry's Law Constant (atm-m^3/g-mole at 25°C)
Methylene Chloride	VOC	84.94	434.9	13,000	1.25	2.69×10^{-3}
o - Xylene	VOC	106.16	6.6	175	3.12	5.1×10^{-3}
Naphthalene[2]	PAH	128.16	0.082	31.7	3.30	4.83×10^{-4}
Benzo(a)pyrene[2]	PAH	252	5×10^{9}	0.0038	6.04	-

Notes:

1. Data taken from Howard (1989 and 1990) except as noted.
2. Data taken from EPA (1979). Henry's Law Constant values were not available.

Table 7
Results of Level I Fugacity Modelling

Component	Percentage of Component in Each Environmental Compartment at Equilibrium			
	Bulk Air	Bulk Water	Bulk Soil	Bulk Sediment
Methylene Chloride	93.85	6.14	0.01	0.00
o-Xylene	95.37	4.44	0.18	0.01
Naphthalene	62.71	35.02	2.10	0.17
Benzo(a)pyrene	0.86	5.69	86.53	6.92

Since the Fugacity Level I model bases predictions of environmental fate solely on physical/chemical properties and considers only organic chemicals, the following paragraphs on each of the components of interest have been provided to summarize literature information on the relative importance of various fate mechanisms including:

- Evaporation
- Adsorption
- Degradation through biodegradation, photolysis, hydrolysis, etc.
- Migration in water

These paragraphs also attempt to describe the fate of releases to land since this is the scenario involved in the use of dust suppressants, as well as the movement of the chemical through the environment as equilibrium is approached.

Where available, information on concentrations of each of the components in various environmental media is also provided.

Methylene Chloride

Releases of methylene chloride to land will evaporate from near-surface soils due to the high vapour pressure of this substance. Once in the atmosphere, reaction with photolytically produced hydroxyl radicals will occur with a half-life of a few months. It is not expected to adsorb significantly to soil particles and some leaching may occur. Degradation in groundwater is unknown. Hydrolysis in soil or water will not normally be an important fate mechanism. In surface waters, biodegradation is possible but will most likely be slow due to the domination of the evaporation process.

There are no natural sources of methylene chloride. Surface water concentrations are typically less than 10 µg/L with median values closer to 0.1 µg/L. Canadian municipal drinking supplies have concentrations up to 50 µg/L, with an average of 10 µg/L in summer and 3 µg/L in winter.

o-Xylene

Evaporation and leaching are both significant fate processes for o-xylene released to land. Upon evaporation, the compound will react rapidly with photolytically produced hydroxyl radicals. The half-life of this reaction varies from 1.5 hours in summer to 15 hours in winter. Biodegradation in soil will occur under aerobic and anaerobic/denitrifying conditions. A lag time of up to six months may be required before biodegradation commences under anaerobic conditions. o-Xylene is moderately mobile in ground water. Some adsorption to soil and sediment is likely and o-xylene has remained detectable in soil and ground water for several years at some sites (Howard, 1990).

Natural sources of o-xylene include coal tar, petroleum, forest fires, and volatilization from plants. Surface waters are generally less than 1 µg/L (Howard, 1990).

Naphthalene

Releases of naphthalene to land are moderately adsorbed by soil particles and also undergo biodegradation. Evaporation will be important only for naphthalene in the very near surface layer. Half-lives for biodegradation may be as short as a few hours to

days if organisms have been previously acclimated, but as long as a few months if not. In water, volatilization, photolysis, sorption and biodegradation are all important fate mechanisms. In air, photochemically produced hydroxyl radicals rapidly react with naphthalene, as well as nitrates found in polluted urban night air (Howard, 1990).

Natural sources of naphthalene include crude oil and any natural, uncontrolled combustion such as forest fire. Natural surface waters may contain up to 2 µg/L (Howard, 1990).

Benzo(a)pyrene

Benzo(a)pyrene (BaP) is a polynuclear aromatic hydrocarbon consisting of five aromatic rings. It has extremely low solubility and vapour pressure and a strong affinity for the organic phase, as indicated by a high octanol water partition coefficient. Therefore, releases of BaP on land will be subject to relatively little evaporation or runoff in a dissolved form. The compound will adsorb strongly to soil particles, especially in organically rich soils. Long term leaching of soil bound BaP may occur. In surface water, direct photolysis will probably occur at a rapid rate, while slow biodegradation and biotransformation will also contribute to ultimate fate (EPA, 1979).

Metals

None of the metal contaminants present in the diluted DCS-225 sample were at concentrations above relevant guideline levels for soils. In a study for the Ontario Ministry of the Environment (Acres, 1988), metals were measured in road surface materials treated with waste crankcase oil and industrial waste oil, as well as in road ditches near the treated site. Despite the fact that metal concentrations in both waste oils were higher than measured in DCS-225 sampled for this study, there was no indication that road materials, road side ditches, and vegetation metals levels were higher than background levels as a result of applications. Thus, metals in waste oils were not considered to cause significant environmental impacts. Therefore, because levels were significantly lower in DCS-225, these should not be of environmental concern.

Phosphorus

The total concentration of phosphorus in DCS-225 was measured to be 153 mg/L. Phosphates released to land will rapidly runoff under saturated soil conditions. Downward movement will occur when soil is not completely saturated. In the soil, adsorption to soil particles is possible but not a dominant fate mechanism. Most phosphates penetrating the soil will be carried with the groundwater. Phosphates are indefinitely persistent in both surface and groundwater. They are nutrients for aquatic life and can stimulate growth of algae. Excess amounts contribute to long term eutrophication. No

phosphates will enter the atmosphere from a release to land. Phosphates are neither bioaccumulative nor bioconcentrative.

SUMMARY

No field studies of the environmental impacts of DCS-225 were identified. The results of the component-based assessment indicate the following:

- Volatile organic compounds such as o-xylene, methylene chloride and light or PAH compounds such as naphthalene will be subject to both evaporation and leaching from releases on land.

- Heavier PAH's such as benzo(a)pyrene may persist at the application site for substantial periods of time, although some leaching and biodegradation may also occur.

- Metals present in DCS-225 are not at concentrations that appear to be significant to the environment.

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P.O. BOX 100
THOROLD, ONTARIO, L2V 3Y8
(416) 227-4142 :

T DCS-225

SECTION 1 : MANUFACTURER INFORMATION

NORJOHN LTD (EMULSION DIV.)

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(416) 227-4142

WHMIS CLASSIFICATION.....CLASS D, DIVISION 2(B): MATERIALS CAUSING OTHER TOXIC EFFECTS.
T.D.G. CLASSIFICATION.....NOT REGULATED
PRODUCT NAME.....DCS-225
CHEMICAL FORMULA.....COMPLEX HYDROCARBON MIXTURE
CHEMICAL FAMILY.....PETROLEUM HYDROCARBONS
MATERIAL USE.....DUST CONTROL

SECTION 2 : HAZARDOUS INGREDIENTS

ZARDOUS INGREDIENTS	%	T.L.V.	C.A.S. #	LD/50, ROUTE, SPECIE	LC/50, ROUTE,
TTY ACID	1.0-5.0%	Nav		74000 Mg/Kg (ORAL/RAT)	Nav
TTY ACID	1.0-5.0%	Nav		Nav	Nav
TTY ACID	3.0-7.0%	Nav		Nav	Nav
TTY ACID	1.0-5.0%	Nav		Nav	Nav
TUMENS	0.5-1.5%	5 mg/m3	8052-42-4	NAv	NAv
TER	80-90%	NAv	7732-18-5	NAv	NAv

WHMIS TRADE SECRET EXEMPTION.....A TRADE SECRET EXEMPTION APPLICATION HAS BEEN FILED WITH THE HAZARDOUS MATERIALS INFORMATION REVIEW COMMISSION AS OF 90/05/25. THE REGISTRY NUMBER ASSIGNED TO THIS PRODUCT IS #2524.

SECTION 3 : PHYSICAL DATA

PHYSICAL STATE.....LIQUID
ODOR.....SULPHOROUS ODOUR
ODOR THRESHOLD.....NAv
VAPOR PRESSURE (mmHg).....NAv
VAPOUR DENSITY (AIR=1).....NAv
BY VOLUME.....NAv
BY WEIGHT.....NAv
EVAPORATION RATE.....NAv
BOILING POINT.....100 DEG. C.
FREEZING POINT:.....0 DEGREES C. FOR WATER PHASE
pH.....6-8
SPECIFIC GRAVITY (WATER=1).....NAv
SOLUBILITY IN WATER (% W/W).....COMPLETE

MATERIAL SAFETY DATA SHEET : 00000011
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DUCT : DCS-225

COEFFICIENT OF WATER\OIL.....NAv
DIST.

SECTION 4 : FIRE & EXPLOSION DATA

FLAMMABILITY.....NOT FLAMMABLE
IF YES, UNDER WHICH
CONDITIONS?
EXTINGUISHING MEDIA.....CARBON DIOXIDE, DRY CHEMICAL, WATER SPRAY, FOAM
SPECIAL PROCEDURES.....FIREFIGHTERS SHOULD WEAR SELF-CONTAINED BREATHING APPARATUS.
FLASH POINT (C), METHOD.....NAv
AUTO IGNITION TEMPERATURE.....NAv
UPPER FLAMMABLE LIMIT (% BY.....NAv
VOL.)
LOWER FLAMMABLE LIMIT (% BY.....NAv
VOL.)
HAZARDOUS COMBUSTION PRODUCTS....CARBON DIOXIDE
CARBON MONOXIDE
SULFUR DIOXIDE

EXPLOSION DATA
SENSITIVITY TO STATIC.....NAv
DISCHARGE
SENSITIVITY TO IMPACT.....NAv
RATE OF BURNING.....NAv

SECTION 5 : REACTIVITY DATA

CHEMICAL STABILITY:
YES.....YES, KEEP AWAY FROM HEAT, SPARKS, OPEN FLAMES.
NO, WHICH CONDITIONS?
COMPATABILITY WITH OTHER
SUBSTANCES:
YES
NO, WHICH ONES?.....STRONG ACIDS
STRONG BASES
STRONG OXIDIZING AGENTS.
REACTIVITY CONDITIONS?.....MAY IGNITE IF OVERHEATED OR IN THE PRESENCE OF STRONG OXIDIZERS
HAZARDOUS PRODUCTS OF.....CARBON MONOXIDE, CARBON DIOXIDE,
DECOMPOSITION
SULFUR DIOXIDE

SECTION 6 : TOXICOLOGICAL PROPERTIES

ROUTE OF ENTRY:
SKIN CONTACT.....CONTACT WITH HOT PRODUCT MAY RESULT IN BURNS.
PROLONGED OR REPEATED CONTACT MAY CAUSE IRRITATION AND/OR DERMATITIS
SKIN ABSORPTION.....NOT ABSORBED THROUGH THE SKIN
EYE CONTACT.....CAN CAUSE SEVERE IRRITATION AND SWELLING OF EYE TISSUES (CONJUNCTIVITIS)
AND CORNEAL BURNS.

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: DCS-225

	MAY CAUSE PERMANENT EYE DAMAGE IF CONTACT NOT ELIMINATED IMMEDIATELY.
INHALATION.....	MAY CAUSE MODERATE IRRITATION TO THE RESPIRATORY TRACT. MAY AFFECT THE CENTRAL NERVOUS SYSTEM.
INHALATION, CHRONIC.....	MAY CAUSE IRRITATION AND DERMATITIS.
INGESTION.....	MAY CAUSE IRRITATION OF THE GASTROINTESTINAL TRACT.
EFFECTS OF ACUTE EXPOSURE.....	REFER TO ROUTE OF ENTRY
EFFECTS OF CHRONIC EXPOSURE.....	REFER TO ROUTE OF ENTRY
LD 50 OF MATERIAL, SPECIES & ROUTE.....	UNKNOWN
LC 50 OF MATERIAL, SPECIES & ROUTE.....	UNKNOWN
EXPOSURE LIMIT OF MATERIAL.....	UNKNOWN
IRRITANCY OF MATERIAL.....	REFER TO ROUTE OF ENTRY
SENSITIZING CAPABILITY OF MATERIAL.....	UNKNOWN
CARCINOGENICITY OF MATERIAL.....	PETROLEUM FRACTION INCLUDES MANY NATURALLY OCCURRING POLYCYCLIC AROMATIC HYDROCARBONS (PAE"s). CERTAIN SPECIES OF PAE"s HAVE BEEN IMPLICATED IN THE INCIDENCE OF SKIN CANCER IN TEST ANIMALS.
REPRODUCTIVE EFFECTS.....	NONE KNOWN
SYNERGISTIC MATERIALS.....	NONE KNOWN

SECTION 7 : PREVENTATIVE MEASURES

GLOVES/ TYPE.....	GLOVES WITH GAUNTLETS. DO NOT WEAR NATURAL RUBBER OR PVC (POLYVINYL CHLORIDE) GLOVES.
RESPIRATORY/TYPE.....	NOT REQUIRED UNDER NORMAL CONDITIONS. IN ENCLOSED AREAS, WEAR APPROVED AIR PURIFYING RESPIRATOR FOR DUST/FUMES/MIST AND ORGANIC VAPOURS OR SUPPLIED AIR RESPIRATOR.
EYE/TYPE.....	SPLASH PROOF CHEMICAL GOGGLES OR 8" FACE SHIELD
FOOTWEAR/TYPE.....	IMPERVIOUS SAFETY BOOTS.
CLOTHING/TYPE.....	LONG SLEEVE, LOOSE FITTING CLOTHING, CLOSED AT THE NECK AND TIGHT FITTING AT THE WRIST. HAVE CONTAMINATED CLOTHING WASHED BEFORE RE-USE.
ENGINEERING CONTROLS.....	MECHANICAL VENTILATION RECOMMENDED IN ENCLOSED AREAS.
LEAK/SPILL.....	CONTAIN THE SPILL. ABSORB WITH SAND, CLAY, ETC. ELIMINATE ALL SOURCES OF IGNITION.
WASTE DISPOSAL.....	ABSORPTION OR CONTROLLED BURNING. PLACE ABSORBANT IN CLOSED CONTAINERS AND DISPOSE IN ACCORDANCE WITH MUNICIPAL, PROVINCIAL AND FEDERAL REGULATIONS.
HANDLING PROCEDURES AND EQUIPMENT.....	AVOID SKIN AND EYE CONTACT.
STORAGE NEEDS.....	STORE AWAY FROM OXIDIZING MATERIALS AND ALL SOURCES OF IGNITION. KEEP CONTAINER CLOSED WHEN NOT IN USE. KEEP FROM FREEZING.
SPECIAL SHIPPING INSTRUCTIONS....	PRODUCT IS SHIPPED AT ELEVATED TEMPERATURES.

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ODUCT : DCS-225

SECTION 8 : FIRST AID MEASURES

EYE CONTACT.....	IMMEDIATELY FLUSH EYES WITH WATER FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION.
INGESTION:.....	SEEK MEDICAL ATTENTION IMMEDIATELY.
INHALATION.....	REMOVE VICTIM TO FRESH AIR. IF BREATHING HAS STOPPED PROPERLY TRAINED PERSONNEL SHOULD BEGIN ARTIFICIAL RESPIRATION. GET MEDICAL ATTENTION IMMEDIATELY!
SKIN CONTACT.....	REMOVE FROM SKIN BY WIPING AND WASH THOROUGHLY WITH SOAP AND WATER. BABY OIL IS HELPFUL IN REMOVING RESIDUAL MATERIAL. BURNS - DO NOT ATTEMPT TO REMOVE ASPHALTIC MATERIAL. SEEK MEDICAL ATTENTION IMMEDIATELY.

SECTION 9 : PREPARATION INFORMATION

PREPARED BY:.....	HEALTH AND SAFETY DEPARTMENT
CONTACT PERSON:.....	BRUCE ROGERS - OCCUPATIONAL HEALTH AND SAFETY CO-ORDINATOR
EMERGENCY TELEPHONE NUMBER:.....	(416) 227-4142
**********	**********
	*****
DISCLAIMER:.....	NORJOHN LTD BELIEVES THE INFORMATION CONTAINED HEREIN TO BE ACCURATE; HOWEVER, THE DATA AND INFORMATION ARE PRESENTED WITHOUT ANY REPRESENTATIO OR WARRANTY, EXPRESSED OR IMPLIED, REGARDING THEIR ACCURACY OR CORRECTNESS. ONCE THIS PRODUCT LEAVES THE PROPERTY OF NORJOHN LTD, THE CONDITIONS OR METHODS OF HANDLING, STORAGE, USE AND DISPOSAL ARE BEYOND THE CONTROL AND KNOWLEDGE OF NORJOHN LTD. FOR THIS AND OTHER REASONS, NORJOHN LTD DOES NOT ASSUME RESPONSIBILITY AND EXPRESSLY DISCLAIM LIABILITY FOR ANY LOSS, DAMAGE, INJURY OR EXPENSE ARISING OUT OF OR IN AN WAY CONNECTED WITH THE HANDLING, STORAGE, USE OR DISPOSAL OF THIS PRODUCT
DATED.....	Jun.14/90

APPENDIX E.6

Dust Bond

REVIEW PARAMETER LIST FOR DUST BOND

A. GENERAL INFORMATION

Dust Bond is a mixture of petroleum resin (60 percent by weight), emulsifier and water (40 percent by weight). It is light in colour with a slight oil odour that dissipates within 24 hours of application on roads. Dust Bond is used only for road dust suppression and road stabilization. It is sold in concentrated form and diluted with water in a five to one, water to concentrate ratio, for application.

SUPPLIER/DISTRIBUTER INFORMATION

Manufacturer Information

Dust Allayers, Inc.
P.O. Box 1178
Mansfield, Ohio 44901

Contact: Mr. Dick Bakir
Phone: (419) 525-4988
Fax: (419) 525-0688

Supplier Information

Da-Lee Dust Control
350 Jones Road
Box 14
Fruitland, Ontario
L0R 1L0

Contact: Ms. Donna Didtrek
Phone: (416) 643-1135
Fax: (416) 643-2299

Applicators/Contractors Information

Donna Didtrek of Da-Lee can be contacted for names of the applicators, other than themselves, to whom they sell Dust Bond concentrate.

COST INFORMATION

Dust Bond is usually sold by Da-Lee Dust Control to other contractors in concentrate form at $0.50/L. At the normal product dilution, this results in a cost of about $0.10/L (1991) for road applied material.

Transportation costs are included in the application cost. Costs vary depending on the distance that the product must be transported from Da-Lee, located in Fruitland, Ontario. Costs are in the range of $0.013/L per 100 km (1991).

Typical application costs for road applied Dust Bond (diluted concentrate at 5:1 water:product ratio) is $0.19/L (1991). At application rates of 5.4 L/m^2 suggested by Da-Lee this equates to $1.03/$m^2$.

SAFETY PROCEDURES

The following procedures are recommended by the manufacturer in the handling of Dust Bond.

Personal Protection

1. Operators should wear impervious gloves under normal handling conditions.

2. Operators should wear chemical type goggles or face shield to prevent eye contact during normal handling or if eye contact is likely.

3. Operators should wear NIOSH[1] approved respirators if exposure to mist is possible.

Emergency First Aid

First aid procedures are listed in the attached Material Safety Data Sheet for Dust Bond.

Storage Requirements

Dust Bond should not be stored near any sources of ignition. Dust Bond containers should be kept tightly closed and not stored near areas where they may come in contact with strong oxidizers (such as hydrogen peroxide, bromine and chromic acid).

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[1] National Institute for Occupational Safety and Health

Transportation and Shipping

No special handling procedures are required other than those required for the transportation of industrial liquid oil products.

Spill Procedures

In accordance with Part 9, Section 79 of the Environment Protection Act, a spill is defined as any discharge, intentional or unintentional, of material from its containing unit beyond the recommended maximum application rate, into the natural environment. This is caused by spray bars left on after operation, tank rupture, tank turn over, etc. In the event of a spill the following procedures are recommended:

1. If possible, the spilled Dust Bond should be contained in a ditch or within the road allowance, and prevented from entering watercourses and storm sewers.

2. As much of the Dust Bond as possible should be recovered with pumping equipment.

3. The remainder of the spill should be absorbed in vermiculite, dry sand, earth, or similar material which should them be disposed of in an approved manner.

4. The following should be contacted:

   - Da-Lee Dust Control: (416) 643-1135
   - The Ministry of the Environment Spills Action Centre: (800) 268-6060.
   - Environment Canada at The Ontario Regional Environmental Emergencies line: (416)-973-1059, or (416)-346-1971 (cellular).
   - The local municipality in which the spill occurred.

SOURCE DESCRIPTION AND QUALITY CONTROL

Dust Bond is imported by Da-Lee Dust Control from Dust Allayers Inc. in the U.S. where the formulation and mixing of the Dust Bond concentrate is carried out. Dust Bond is a proprietary blend of specified petroleum oils (from a major U.S. oil company) and a proprietary emulsifier (DAI Emulsions, 1991). Da-Lee Dust Control adds water to the imported concentrate. The diluted concentrate is mixed in a 227,000 L mixing tank to generate a mixture ready for road application.

Minimal quality control occurs in Ontario. Dust Bond arrives at Da-Lee Dust Control as specified by Dust Allayers Inc. Once at Da-Lee Dust Control, Dust Bond is stored until it is required for mixing or sale to other applicators. Flow pumps are monitored

as well as tank levels to ensure proper mixing concentrations. No other quality control tests are carried out.

B. TECHNICAL EFFECTIVENESS AND APPLICATION PROCEDURES

TECHNICAL EFFECTIVENESS

Dust Bond is used primarily as a dust suppressant, but may also be used as a road stabilizer. A formulation of petroleum resins, emulsifiers, and water, it behaves similarly to oil, by controlling dust through wetting of the road surface aggregate and agglomerating fines, and thus preventing them from becoming airborne.

To evaluate the technical effectiveness of Dust Bond, information was obtained via two principal sources. A telephone survey of current or past users of Dust Bond in Ontario, was carried out by CH2M HILL as part of the present study. In addition, due to the limited information on Dust Bond, a literature survey of similar emulsified petroleum resins used as dust suppressants was also carried out to supplement information available on the technical effectiveness of Dust Bond. To this end, literature on Coherex (an emulsified petroleum resin) was also reviewed as part of the literature search.

In the CH2M HILL telephone survey, dust suppressant users at industrial sites expected that Dust Bond would perform similar to oil in controlling dust. However, the experience of users surveyed was that Dust Bond exhibited half the effective lifetime that oil traditionally has had.

In an Ontario Ministry of Transportation study in the district of Parry Sound, (Ontario, 1989), Dust Bond was compared to other products tested as potential replacements to used oil. Normally diluted Dust Bond (5 parts water to 1 part Dust Bond) was applied at a rate of 1.83 L/m^2 (less than half the recommended rate of 4 L/m^2) on roads that had either 50 percent new gravel float, or were 50 percent previously oiled roads. No vehicular traffic measurements, rain levels, or silt concentrations were reported. Dust suppression effectiveness was measured over 3.5 months using a subjective rating scale. Under these municipal road conditions Dust Bond had a 3 month lifetime. Although penetration onto the freshly gravelled surface was 20 mm, compared to 6 mm in the previously oiled surface, no difference in dust control and pothole prevention was observed between the two surfaces over the 3.5 months. This indicated Dust Bond's compatibility with fresh and previously oiled surfaces. However, the road was subject to overall potholing and washboarding as a result of wet weather traffic. This necessitated maintenance grading which noticeably reduced the dust controlling effectiveness of Dust Bond, but not to the point of needing reapplication.

Although rain can have a negative effect on a dust suppressant's road stabilizing characteristics by promoting potholing, pitting, and corrugations, it can also aid in dust suppression. In a field study carried out by The Midwest Research Institute (1984) to study the long term effectiveness of various dust suppressants used on haul roads in the

iron and steel industry, Petro Tac (an emulsified asphalt resin), was compared to Coherex (an emulsified petroleum resin). Two plant sites were chosen as test sites. Isokinetic profiling was used to measure controlled and uncontrolled dust emissions. Coherex was tested at the first site, where rain was 6.6 cm over the 4 month test period. Petro Tac was tested at the second site, where 38.8 cm of precipitation occurred over the 4 month test period. Petro Tac was effective as a dust control agent for 100,000 vehicle passes while Coherex was effective for only 7,500 vehicle passes. Although Petro Tac is an emulsified asphalt resin, and Coherex is an emulsified petroleum resin, some of the superior dust suppression performance of Petro Tac over Coherex was attributed to the higher rainfall which would aid in dust suppression. In a subsequent field test at the Kansas City Works plant with the same level of precipitation, Coherex and Petro Tac performed similar to one another (The Midwest Research Institute, 1987).

In the same iron industry field study (The Midwest Research Institute, 1984), the average weight of the vehicles passing over the Coherex section at the first site was 34 tonnes, while at the second site was 27 tonnes. Some of Petro Tac's longer effective lifetime over Coherex's was attributed to the lower traffic weight. In a subsequent field test (The Midwest Research Institute, 1987), Coherex and Petro Tac had very similar performance results to one another under similar traffic loads (220 to 260 vehicles per day), traffic weights (8.4 tonnes/vehicle), and application rates.

In Midwest Research Institue (1987) iron works study the site treated with Coherex had a silt content of 13.9 percent, and the emulsified petroleum resin demonstrated a higher level of control efficiency for 2.5 µm particles than for the larger particles between 15 and 75 µm. In contrast, the 1984 iron works study showed Coherex had the same control efficiency for 2.5 µm particles as for 15-75 µm particles with the first application. After the second application, 44 days later, Coherex showed more dust control efficiency improvements for particles between 15 and 75 µm than for particles less than 2.5 µm. Although this indicates that different size fractions of fines will be controlled at different levels of efficiency. No clear relationship between particle size and control efficiency could be drawn from these tests.

Another field study that indicated a relationship between dust control efficiency and control of fines was a steel industry study carried out on roads in the Pittsburg area (Russel, 1983). This study showed that Coherex's ability to agglomerate particles (such that they could not pass through the 75 µm mesh screen) was proportional to its ability to suppress dust. Road silt, hi-vol air sampling and time lapse photography were used to measure technical effectiveness. The road silt concentration was 7 percent in this study.

Summary of Overall Performance

The performance of Dust Bond, or an emulsified petroleum resin in general, is dependent on several factors, including:

1. Dust Bond, and emulsified petroleum resins in general, function by wetting the surface of fine particles, which causes them to agglomerate and prevents them from becoming airborne.

2. The effective lifetime varies with location, surface preparation and traffic loads applied. Heavier weight and higher volume traffic decrease life span.

3. Dust Bond applications may not protect a road from frequent potholing and pitting during rainy weather, since it does not bind the surface. It may act as a lubricant to fines in wet weather.

4. Roads treated with Dust Bond can be maintenance graded to remove potholes and corrugations at the loss of some, but not all dust control.

5. Extremely dry weather may reduce an emulsified petroleum resin's ability to control dust.

6. An emulsified petroleum resin's dust suppressing ability is directly related to its ability to agglomerate fine particles in the road surface material.

7. Emulsified petroleum resins will control different size fractions of fines particles with different levels of efficiency. No relationship between fines diameter and control efficiency can be concluded from the cited literature.

8. Dust Bond is compatible with previously oiled surfaces as well as freshly graded and gravelled surfaces.

APPLICATION PROCEDURES

Site Restrictions

According to the Ontario Ministry of Environment's Draft Guidelines for the Application of Dust Suppressants, dust suppressants should not be applied to sites closely adjacent to or crossing waterway(s) or marshes, or near wells.

Surface Preparation

Published information from Da-Lee or the municipalities for the preparation of road surfaces prior to Dust Bond application was not identified in the information search. Information is based on the telephone survey conducted with current users and Da-Lee. Preparation should be as follows:

1. Proper drainage should be provided for the road surface on both sides of the road or for the yard.

2. The surface should be graded to a significant depth (20 to 50 mm) to remove pot holes, corrugations and other ruts. If the road is deeply rutted or corrugated it may require scarification up to 100 mm.

3. Gravel or fines should be added as required to yield a final composition of 10 to 15 percent fines (< 200 mesh) (UMA Engineering Ltd., 1987).

4. The road should be shaped to the correct crown (about 4 percent straight line) using a grader equipped with a straight flat blade.

5. The Dust Bond should be applied at desired levels while the surface is still a little moist to prevent dust coated beads on the surface which prevents penetration.

6. If the road or surface is being constructed, compaction of the surface is suggested to provide a firm solid base.

Length of Time Before and After Precipitation

Current and past users of Dust Bond have recommended that if heavy rainfall is forecast within 24 hours, application of Dust Bond should be postponed until after such rainfall. Dust Bond should be applied within 12 to 24 hours after a significant rainfall while the road has some moisture remaining. Under these conditions, runoff due to rain will be avoided.

Application Equipment

Application equipment for petroleum based products is usually a bituminous distributor. The Ontario Ministry of Transportation requires that the distributer be equipped with a pump capable of developing a constant uniform pressure in the spray bar manifold. In addition, the spray bar must be capable of application over a variety of widths. The distributor tank should also come equipped with a dip stick for measuring quantities applied.

The equipment list for bituminous distributors also contains the following:

- Recirculation in the tank.
- A quick opening gate in the dome.
- An external readily visible tank gauge.

- Rear mounted spray bars and nozzles 0.6 to 3.6 m wide capable of:
  - vertical and lateral adjustment
  - producing double coverage in one pass.

- Spray bars must not extend into the lane of opposing traffic unless adequate warning measures are taken.

- The feed to the spray bars should be equipped with:
  - recirculation before and during operation
  - filters.

- Spray nozzles should be:
  - fitted with instant on/off valves, and
  - which yield fan-shaped sprays without atomization.

- A pressure pump capable of supplying approximately 726 L/min of oil.

- An operator visible 345 MPa pressure gauge.

- An operator visible flow meter.

- An operator visible pump tachometer.

Personnel Requirements

Typically, two to four people are required for safe application of dust suppressants. This would consist of at least one, maybe two, flag-persons and/or an operator of a warning pilot vehicle, the operator of the application truck, and an application checker (the flag person can double as a checker).

Dilution

Dust Bond is to be mixed with five parts water to one part Dust Bond for optimum performance. Dust Bond should not be mixed with any other materials, especially any strong oxidizing agents such as hydrogen peroxide bromine, and chromic acid.

Application Rate and Frequency

Da-Lee has recommended various application rates depending on the traffic load. These rates are summarized below:

Traffic Level	First Application		Second Application (L/m^2)	Third Application (as needed when dust reoccurs) (L/m^2)	Yearly Total (L/m^2)
	First Pass (L/m^2)	Second Pass (L/m^2)			
Light to medium <250 ADT[1] (cars and pick up)	1.35	1.35	1.35 (2 weeks later)	1.35	5.4
Heavy >250 ADT[1]	1.35	1.35	2.7 (2 weeks later)	No mention of	5.4
Large trucks (dumps, semis)	5.4	none	2.7 (2-4 weeks later)	1.35	9.45

Notes:

1. Average daily traffic.

These application rates are based on the recommended 5:1 water to Dust Bond diluted products.

Ponding should be avoided during application. Ponding will depend on several factors; the rate of Dust Bond discharge, the speed of the application truck, and the porosity of the surface materials. Ponding can be prevented by shutting off the spray bars when the vehicle/truck is stopped or is passing over paved/sealed portions of the road. Care should also be taken to ensure that the liquid is applied at or below the suggested rates. If ponding still occurs then a decrease in the application rate is necessary.

Curing Time

Dust Bond does not have a curing time. It takes about 20 minutes to soak into the surface after which no other changes occur. Traffic should be restricted to slower speeds for 1/2 hour after spraying to permit maximum penetration and to avoid excessive tracking onto cars.

Problems and Hazards

Roads may be slippery after periods of significant rainfall.

C. PHYSICAL AND CHEMICAL CHARACTERISTICS

PHYSICAL PROPERTIES

Table 1 is a summary of the physical properties of undiluted Dust Bond.

Table 1 Physical Properties of Dust Bond	
Property	**Dust Bond**
Odour	Hydrocarbon
Appearance	Light yellow brown
Physical state when applied	Viscous liquid
Physical state when dried	Viscous liquid
pH	4.5 - 6.5
Solubility in water	Readily dispersible
Evaporative rate	Same as water
Vapour pressure	Same as water
Flammability/flash point	>204 °C
Boiling point	100 °C
Freezing point	-51 °C
Specific gravity	1
Source: Dust Bond Material Safety Data Sheet from Da-Lee Dust Control, 1989.	

CHEMICAL COMPOSITION

Dust Bond is composed of the following:

- Petroleum resin (distillate) - 60 percent by weight.
- Emulsifier and water - 40 percent by weight.

The chemical properties of Dust Bond were analyzed by CANVIRO Analytical Laboratories Ltd on a sample of undiluted Dust Bond which was provided by Da-Lee for this study. The sample was diluted with tap water in the laboratory in the prescribed 5 to 1 ratio, and split for duplicate analyses of conventional parameters, metals, polynuclear aromatic hydrocarbons (PAH) and volatile organic compounds (VOC). Table 2 presents the analytical results.

A few metals, including aluminum, boron, copper, iron, manganese and zinc, were present in low concentrations ranging up to 1.7 mg/L. Several PAH compounds in the lighter, middle and heavier ranges were detected in concentrations ranging from 41 µg/L (acenaphthylene) to 22,300 µg/L (pyrene). Only a few VOCs were present, with the most prominent being methylene chloride, at 9,175 µg/L.

Table 2
Analytical Data for Chemical Characteristics of Dust Bond[1]

	Units	Concentration
Conventional Parameters		
pH		4.9
Total solids	mg/L	119,000
BOD_5	mg/L	(2)
Ammonium Nitrogen'	mg/L	30
Total Phosphorus	mg/L	102
Oil & Grease	mg/L	138,000
Metals		
Aluminum	mg/L	0.135
Boron	mg/L	0.065
Barium	mg/L	<0.01
Beryllium	mg/L	<0.005
Cadmium	mg/L	<0.012
Calcium	mg/L	3.51
Chromium	mg/L	<0.02
Cobalt	mg/L	<0.03
Copper	mg/L	0.025
Iron	mg/L	1.69
Lead	mg/L	<0.1
Magnesium	mg/L	0.765
Manganese	mg/L	0.015
Vanadium	mg/L	<0.01
Zinc	mg/L	0.05
Nickel	mg/L	<0.02
Silver	mg/L	<0.02
Strontium	mg/L	0.015
Sodium	mg/L	<5
Arsenic	mg/L	<0.05
Selenium	mg/L	<0.01
Mercury	mg/L	<0.001
Polynuclear Aromatic Hydrocarbons		
Naphthalene	µg/L	85.6
Acenaphthylene	µg/L	<3.2
Acenaphthene	µg/L	41.2
Fluorene	µg/L	103.5
Phenanthrene	µg/L	1,215
Anthracene	µg/L	<6.4
Fluoranthene	µg/L	2,975
Pyrene	µg/L	22,300
Benzo (a) anthracene	µg/L	<4
Chrysene	µg/L	2,775
Benzo (b) fluoranthene	µg/L	2,275
Benzo (k) fluoranthene	µg/L	(3)
Benzo (a) pyrene	µg/L	3,455
Indeno (1,2,3-cd) pyrene	µg/L	<8.8
Dibenzo (a,h) anthracene	µg/L	<6.4
Benzo (ghi) perylene	µg/L	5,115

Table 2
Analytical Data for Chemical Characteristics of Dust Bond[1]

	Units	Concentration
Volatile Organic Compounds		
Chloromethane	µg/L	<180
Vinyl chloride	µg/L	<250
Bromomethane	µg/L	<100
Chloroethane	µg/L	<80
Trichlorofluoromethane	µg/L	<175
Acrolein	µg/L	<110
1,1-Dichloroethylene	µg/L	<80
Methylene chloride	µg/L	9,175
Acrylonitrile	µg/L	<105
trans-1,2-dichloroethylene	µg/L	<35
1,1-dichloroethane	µg/L	<25
Methyl Ethyl Ketone	µg/L	<55
Chloroform	µg/L	<20
Bromochloromethane	µg/L	<10
1,1,1-Trichloroethane	µg/L	<25
Carbon Tetrachloride	µg/L	<35
1,2-Dichloroethane	µg/L	<15
Benzene	µg/L	<20
Trichloroethylene	µg/L	<95
1,2-Dichloropropene	µg/L	<10
Bromodichloromethane	µg/L	<10
2-Chloroethylvinyl ether	µg/L	<20
trans-1,3-Dichloropropylene	µg/L	<15
cis-1,3-Dichloropropylene	µg/L	<25
Toluene	µg/L	185
1,1,2-trichloroethane	µg/L	<15
Tetrachloroethylene	µg/L	<40
Dibromochloromethane	µg/L	<10
Ethylene dibromide	µg/L	<30
Chlorobenzene	µg/L	<10
m&p Xylene	µg/L	152.5
Ethylbenzene	µg/L	41
Styrene	µg/L	<20
o-Xylene	µg/L	65.5
Bromoform	µg/L	<15
1,1,2,2-Tetrachloroethane	µg/L	<25
1,3-Dichlorobenzene	µg/L	<10
1,4-Dichlorobenzene	µg/L	<5
1,2-Dichlorobenzenne	µg/L	<20

Notes

1 Average of duplicate analyses of diluted Dust Bond (5 parts water to 1 part Dust Bond)
2 Could not be analyzed as it formed a non-domogeneoud emulsion with water
3 Benzo (b) and benzo (k) fluoranthene co-eluted, therefore result is reported as a total
< Below detection limit

D. ACUTE TOXICITY AND SUB-LETHAL EFFECTS

ACUTE TOXICITY

B.A.R. Environmental conducted duplicate acute toxicity tests using the Dust Bond samples provided by Da-Lee for the study. Samples were diluted in the laboratory using tap water to the 5 to 1 ratio. The test measured the LC50 values and their corresponding 95 percent confidence interval on Daphnia magna and rainbow trout. The LC50 is the median lethal concentration (ie. the concentration of the test chemical in water that is estimated to be lethal to 50 percent of the test organism within a prescribed period of time).

The toxicity results presented in Table 3 indicated that an average 535 mg of diluted Dust Bond in 1 L of water is lethal to rainbow trout, and 62.5 mg/L is lethal to Daphnia magna. According to one rating system (IMCO/FAO/UNESCO/WMO, 1969), Dust Bond toxicity rates a Grade 2, on a scale of 0 to 4, where 0 is the least toxic.

Table 3
Acute Toxicity Test Results for Dust Bond

Organism	Test	Dust Bond	
		Concentration (mg/L)	95% Confidence Interval (mg/L)
Rainbow Trout	LC50 (96h)	535	469 - 609
Daphnia Magna	LC50 (48h)	62.5	55 - 71

SUB-LETHAL EFFECTS

Limited information is available on the sub-lethal effect of Dust Bond. To assess the potential sub-lethal effects of Dust Bond, individual chemical components present at concentrations above guidelines and standards for drinking water and/or aquatic life as presented in Table 4, were examined.

Comparing the concentrations of toxic substances in 100 percent strength of the dust suppressant product provides an indication of toxicity to human and aquatic life only a "worst case" basis. Some dilution effects will occur once the material is released to land and exposed to the effects of runoff, leaching and degradation. In addition, concentration of persistent substances after repeated application may also occur. The exact extent of dilution or build-up will depend largely on site specific factors and will not be addressed in generic assessment of sub-lethal effects.

Table 4
Comparison of Contaminant Limits for Drinking Water and Aquatic Life to Concentrations in Dust Bond

Parameter	Aquatic Life	Drinking Water	
Ammonia (mg/L)	0.02 (unionized)[2]	n/a	30
Phosphorus (mg/L)	0.02[2]	n/a	102
Iron (µg/L)	300[2]	300[2,3]	1,690
Naphthalene (µg/L)	n/a	n/a	85.6
Acenaphthene (µg/L)	n/a	n/a	41.2
Fluorene (µg/L)	n/a	n/a	103.5
Phenanthrene (µg/L)	n/a	n/a	1,215
Fluoranthene (µg/L)	n/a	0.2 µg/L[5,6]	2,975
Pyrene (µg/L)	n/a	n/a	22,300
Chrysene (µg/L)	n/a	n/a	2,775
Benzo (b) fluoranthene (µg/L)	n/a	n/a	2,275
Benzo (a) pyrene (µg/L)	n/a	0.2 µg/L[5,6]	3,455
Benzo (ghi) perylene (µg/L)	n/a	0.2 µg/L[5,6]	5,115
Methylene chloride (µg/L)	98[4]	1,750[7]	9,175

Notes:

1. Only parameters with concentrations exceeding referenced limits are presented.
2. Ontario Ministry of the Environment, 1984. Water Management Goals Policies, Objectives and Implementation Procedures of the Ministry of the Environment.
3. Health and Welfare Canada, 1987. Canadian Guidelines for Drinking Water Quality
4. Environment Canada and Welfare Canada, 1991. How safe is Our Water
5. World Health Organization, 1984. Guidelines for Drinking Water Quality Volume 2. Health Criteria and other supporting information.
6. Total for 6 PAH components.
7. Health and Welfare Canada, 1991. Personal Communication Cited from MOE literature.

In the absence of a detailed exposure and risk assessment, it is not possible to completely assess the degree of human of environmental health risk posed by Dust Bond. The following discussion attempts only to identify the contaminants of concern which could potentially cause of problem over the long term. In many cases, the toxological data available is limited.

Main Components

The primary routes of entry of Dust Bond into human bodies, especially for those working directly with the product, are via skin contact, inhalation and ingestion. Dust Bond may cause mild irritation to the eye and digestive tract (Dust Bond MSDS, 1989).

Contaminant Based Assessment

PAH compounds found in Dust Bond have been shown to have teratogenic, mutanogenic and/or carcinogenic properties in animals, and are probable human carcinogens. In additions, PAH may be bioconcentrated in fresh water invertebrates. However, the heavier PAH compounds, such as benzo (a) pyrene, which are those of most concern, are likely to remain closely associated with roadbed materials, and are not very mobile. Therefore, contamination of drinking water, groundwater or surface water is unlikely. Ingestion or inhalation of road dust, or mist during application, may be more likely routes of exposure. There are many natural and anthropogenic sources of PAH.

Only one metal, iron, was present at levels above relevant guidelines. Guidelines for iron are based on aesthetic considerations, and are significantly lower than those of concern to human health. Toxic effects resulting from the iron content in Dust Bond are unlikely.

The carbonaceous (BOD_5) and nitrogenous (ammonia) oxygen demand of Dust Bond would reduce dissolved oxygen in surface waters. Oxygen concentrations of 4 to 8 mg/L (depending on temperature) are necessary for freshwater aquatic life (MOE, 1984). Phosphorus in surface water may promote noxious algae growth. Effects of these components should not be a concern under normal dust suppressant use, and as long as care is taken not to apply the material in the vicinity of surface water.

SUMMARY

The following main points summarize the acute toxicity and sub-lethal effects of Dust Bond:

- Dust Bond, diluted with tap water for road application, is toxic to rainbow trout at 535 mg/L and, to Daphnia magna at 62.5 mg/L.
- Limited data are available on the sub-lethal effects of Dust Bond. It may cause mild irritation and dermititus on skin contact, and irritate eyes and digestive tract.
- PAH compounds in Dust Bond would not likely contaminate water supplies. However, exposure may occur through inhalation of oil mist during application or road dust.
- Volatile organics and metals present in Dust Bond were not at levels that would contribute to toxic or sub-lethal effects.

E. ENVIRONMENTAL IMPACTS

MAIN DUST SUPPRESSANT COMPONENTS

No literature sources describing field studies of the environmental impacts of Dust Bond were identified.

Dust Bond is a mixture, that when diluted with water for road application, is 12 percent petroleum resin and less than 8 percent emulsifier. The petroleum resin is emulsified (in minute droplets), when applied. Its behaviour after application has not been documented, but eventual evaporation of water would likely leave behind the resin, which would agglomerate road materials for dust suppression. This resin will be for the most part, immiscible and has a higher viscosity than water, and therefore, migration will not be affected by water movement. It will migrate from the application site by leaching and penetrating into soil, and will be slowed by soil adsorption. Some components of the resin will solubilize in passing waters and leach away. Lighter fractions of the resin will volatilize, although the portion and rate of volatilization has not been determined. The petroleum fraction of the product is biodegradable, and lighter fractions will biodegrade in the environment more quickly. The overall rate of decay in the environment has not been determined. In soil, the Ontario MOE's guidelines for site clean-up recommend that oil and grease levels should not exceed 1 percent by weight.

In the aquatic environment, slicks or sheen will result, as well as some dissolution of components.

COMPONENT-BASED ASSESSMENT

No studies of the use of Dust Bond which adequately describe environmental impacts were available. Examination of the individual components of the product provide the "next best" assessment of environmental fate. The analytical results presented in Table 5 have been used to develop a short list of components which represent a range of possible fates for Dust Bond which has been applied to land.

Organic Contaminants

In order to assess a range of the persistence and migration characteristics of Dust Bond, a number of the components from the above list have been selected for further discussion.

For assessment of environmental impact of PAH compounds exceeding guideline levels, presented in Table 5, two compounds were selected to represent the range of possible environmental fates for this group of compounds. Pyrene, was on of the lightest compounds in this group while benzo (a) pyrene was one of the heaviest.

Table 5
Comparison of Contaminant Limits in Soil to Levels in Dust Bond

Parameter	Soil Concentrations[2] (µg/kg dry weight)	Dust Bond (µg/L)
Fluorene	n/a	103.5
Phenanthrene	100	1,215
Fluoranthene	n/a	2,975
Pyrene	100	22,300
Chrysene	n/a	2,775
Benzo (b) fluoranthene and benzo (k) fluoranthene	100	2,275
Benzo (a) pyrene	100	3,455
Benzo (ghi) perylene	n/a	5,115
Methylene chloride	100	9,175

Notes:

1. Only parameters with concentrations exceeding referenced levels are presented.
2. Canadian Council of Ministries of the Environment, 1991. Interim CCME Environment Quality Criteria for Contaminanted Sites, Final Draft. These values are interim criteria and are to be considered background or recommended detection limit values.

For organic contaminants, environmental fate and behaviour can be at least partially predicted through a knowledge of physical/chemical properties such as those presented in Table 6 for the selected organic components.

It is difficult to assess the combined effects of all the properties noted in Table 2 based solely on a review of the data. The Fugacity Level I model has been used to achieve a measure of the combined effects of these properties. Results for the chemicals of interest are reported in Table 7. It should be emphasized that this model does not consider which environmental compartments receive releases of the chemical, nor the rate at which equilibrium is achieved. Also not taken into consideration are degradation reactions which may deplete the amount of chemical in the model environment.

Since the Fugacity Level I model bases predictions of environmental fate solely on physical/chemical properties and considers only organic chemicals, discussions on each of the components of interest have been provided to summarize literature information on the relative importance of various fate mechanisms including:

- Evaporation
- Adsorption
- Degradation through biodegradation, photolysis, hydrolysis, etc.
- Migration in water

Table 6
Physical/Chemical Properties of Selected Organic Components of Dust Bond[1]

Component	Component Group	Molecular Weight (g/g-mole)	Vapour Pressure (mm Hg at 25 °C)	Aqueous Solubility (mg/L at 25 °C)	log Octanol-Water Partition Coefficient	Henry's Law Constant ($atm\text{-}m^3$/g-mole at 25°C)
Methylene Chloride	VOC	94.94	434.9	13,000	1.25	2.68×10^{-3}
o - Xylene	VOC	106.16	6.6	175	3.12	5.1×10^{-3}
Naphthalene	PAH	128.16	0.082	31.7	3.30	4.83×10^{-4}
Pyrene[2]	PAH	202	6.85×10^{-7} at 20°C	0.14	5.32	-
Benzo(a)pyrene[2]	PAH	252	5×10^{-9}	0.0038	6.04	-

Notes:

1. Data taken from Howard (1989 and 1990) except as noted.
2. Data taken from U.S. EPA (1979). Henry's Law Constant data were not available.

Table 7
Results of Level I Fugacity Modelling

Component	Percentage of Component in Each Environmental Compartment at Equilibrium			
	Bulk Air	Bulk Water	Bulk Soil	Bulk Sediment
Methylene Chloride	93.85	6.14	0.01	0.00
Naphthalene	62.71	35.02	2.10	0.17
Pyrene	0.16	15.38	78.20	6.26
Benzo(a)pyrene	0.86	5.69	86.53	6.92

These discussions also describe the fate of releases to land, since this is the scenario involved in the use of dust suppressants, as well as the movement of the chemical through the environment as equilibrium is approached.

Where available, information on concentrations of each of the components in various environmental media is also provided.

Methylene Chloride

Releases of methylene chloride to land will evaporate from near-surface soils due to the high vapour pressure of this substance. Once in the atmosphere, reaction with photolytically produced hydroxyl radicals will occur with a half-life of a few months. It is not expected to adsorb significantly to soil particles and some leaching may occur.

Degradation in groundwater is unknown. Hydrolysis in soil or water will not normally be an important fate mechanism. In surface waters, biodegradation is possible but will most likely be slow due to the domination of the evaporation process.

There are no natural sources of methylene chloride. Surface water concentrations are typically less than 10 µg/L with median values closer to 0.1 µg/L. Canadian municipal drinking supplies have concentrations up to 50 µg/L, with an average of 10 µg/L in summer and 3 µg/L in winter (Howard, 1989; Howard, 1990).

Pyrene

Pyrene is a polynuclear aromatic hydrocarbon consisting of four aromatic rings. Much of the information on its environmental fate and behaviour can be inferred from data on similar compounds. Releases of pyrene to land will bind strongly to soil particles of adequate organic carbon content and evaporation will not play a significant role in either short or long term fate. Although only sparingly soluble, leaching of pyrene to the groundwater may occur over the long term, resulting in considerable persistence in the immediate vicinity of the release. In water, pyrene may be subject to photolysis and, to a lesser extent, oxidation. Biodegradation and biotransformation are also believed to play a role in the long term fate of pyrene.

Pyrene is present in the environment due to both natural and anthropogenic sources and has been detected in ambient river water.

Benzo(a)pyrene

Benzo(a)pyrene (BaP) is a polynuclear aromatic hydrocarbon consisting of five aromatic rings. It has extremely low solubility and vapour pressure and a strong affinity for the organic phase, as indicated by a high octanol water partition coefficient. Therefore, releases of BaP on land will be subject to relatively little evaporation or runoff in a dissolved form. The compound will adsorb strongly to soil particles, especially in organically rich soils. Long term leaching of soil bound BaP may occur. In surface water, direct photolysis will probably occur at a rapid rate, while slow biodegradation and biotransformation will also contribute to ultimate fate (U.S. EPA, 1979).

Metals

None of the metal contaminants present in the diluted Dust Bond sample were at concentrations above relevant guideline levels for soils. In a study for the Ontario Ministry of the Environment (Acres, 1988), metals were measured in road surface materials treated with waste crankcase oil and industrial waste oil, as well as in road ditches near the treated site. Despite the fact that metal concentrations in both waste oils were higher than measured in Dust Bond sampled for this study, there was no indication that road materials, road side ditches, and vegetation metals levels were higher than

background levels as a result of applications. Thus, metals in waste oils were not considered to cause significant environmental impacts. Therefore, because levels were significantly lower in Dust Bond, these should not be of environmental concern.

Phosphorus

The total concentration of phosphorus in Dust Bond was measured to be 102 mg/L. Phosphates released to land will rapidly runoff under saturated soil conditions. Downward movement will occur when soil is not completely saturated. In the soil, adsorption to soil particles is possible but not a dominant fate mechanism. Most phosphates penetrating the soil will be carried with the groundwater. They are nutrients for aquatic life and can stimulate increased growth of algae. Excess amounts contribute to long term eutrophication. No phosphates will enter the atmosphere from a release to land. Phosphates are neither bioaccumulative nor bioconcentrative.

SUMMARY

No field studies of Dust Bond were available. The component based assessment indicates that:

- Metals present in Dust Bond are not at concentrations that appear to be significant to the environment.
- Volatile compounds such as methylene chloride, will not persist at the application site and will be rapidly lost to the atmosphere.
- Medium and heavier PAH compounds such as pyrene and benzo (a) pyrene may persist at the application site for long periods of time, although they may be subject to some leaching and/or biodegradation.

643-1135

DA-LEE DUST CONTROL

513125 ONTARIO LIMITED

MAILING ADDRESS
Box 14
Fruitland, Ont.
L0R 1L0

RIAL SAFETY DATA SHEET

FACTURING FACILITY / DISTRIBUTOR : Da-Lee Dust Control
350 Jones Rd., P.O. Box 14,
Fruitland, Ont. L0R 1L0 (416) 643-1135

OF PREPARATION: March 10, 1989

UCT NAME OR NUMBER: DUST BOND

WHMIS - Class D, Div 2

UCT USE: Dust suppression on roadways and parking lots

ION II-HAZARDOUS INGREDIENTS

ICAL COMPONENTS	C.A.S.NUMBER	% WT.	EXPOSURE LIMITS
oleum Resin tillate)	64742-04-7	60	5mg/m^3 (OHSA DEL)
sifier & Water		40	

ION III - PHYSICAL DATA

ICAL STATE	Liquid
ING POINT	212^o F
UR PRESSURE (mmHg@20^{o}C)	same as water
UR DENSITY (air=1)	same as water
BILITY IN WATER	readily dispersible
IFIC GRAVITY	[redacted]1,
ENT VOLATILE BY VOLUME	less than 45^o@ 25^{o}C
ORATIVE RATE (ethyl ether=1)	same as water
	4.5 to 6.5
ZING POINT/MELTING POINT	minus 60^{o}F
ARANCE AND ODOUR	light colour, no objectional odour
R THRESHOLD (ppm)	not avail.
ITY (g/ml)	not avail.
FICIENT OF OIL/WATER DIST.	not avail.

CTION IV - FIRE AND EXPLOSION HAZARD DATA

ASHPOINT	greater than 400°F
TINGUISHING MEDIA	Foam, dry chemical, water spray, CO_2
G FLAMMABILITY CLASS	not applic.
TOIGNITION TEMPERATURE	not avail.
PER EXPLOSION LIMIT	not avail.
WER EXPLOSION LIMIT	not avail.
NSITIVITY TO MECHANICAL IMPACT	not applic.
NSITIVITY TO STATIC DISCHARGE	not applic.
CIAL FIRE-FIGHTING INSTRUCTIONS	fire fighters should wear self-contai breathing apparatus.
CIAL PROCEDURES	- dense smoke, wear self-contained breathing apparatus - exposed material may be cooled with water, - water may cause frothing

TION V - REACTIVITY DATA

BLE	not avail .
OMPATIBILITY (materials to avoid)	- avoid strong oxidizers such as hydrogenperoxi bromine and chromic acid
ARDOUS POLYMERIZATION	- not avail.
ARDOUS DECOMPOSITION PRODUCTS	- Carbon monoxide, Aldehydes and carbon dioxide from burning. Oxides of Nitrogen and sulfer may also be produced.

TION VI - TOXICOLOGICAL PROPERTIES

MARY ROUTE (S) OF ENTRY	skin contact, Inhalation, Ingestion, eyes
0	greater than 16g/K (oral/rat)

ECTS OF EXPOSURE

Inhalation - Prolonged extreme exposure to high concentrations of mist may cause bronchial or lung irritation

Skin Contact - Prolonged skin contact may cause mild irritation and dermatitis.

Eye Contact - May cause mild irritation.

Ingestion - May cuase irritation of the digestive tract.

ION VII - FIRST AID MEASURES

LATION - If a large amount of mist is inhaled, move exposed person to fresh air and call a physician.

- If skin becomes wet, wash exposed area with soap & Water.

- If eye contact occurs, flush eyes with water for 15 minutes.

STION - If swallowed, do not induce vomiting. Call physician immediately. Small amounts which accidentally enter mouth should be rinsed until taste of it is gone.

ION VIII - PREVENTIVE MEASURES

NEERING CONTROLS (eg. ventilation, enclosed process)

- Use local exhaust or dilution ventilation if exposures exceed permissible limit.

ONAL PROTECTIVE EQUIPMENT

ES - Impervious gloves recommended

- Chemical type goggles or face shield should be used as splashes to eye may occur

HING - Wash clothing before re-use

IRATORY PROTECTION - NIOSH approved if over exposure to mist occurs.

ION IX - STORAGE AND HANDLING

AGE REQUIREMENTS - keep containers tightly closed

LING PROCEDURES AND EQUIPMENT - Avoid strong oxidizers.

- Avoid prolonged or repeated contact with skin or breathing vapours, mists or fumes.
- Launder contaminated clothing before re-use
- Wash thoroughly after handling.
- Do not use near sources of ignition such as flames or sparks.

ION X - SPILL AND LEAK PROCEDURES

AN-UP - Absorb in vermiculite, dry sand, earth or similar material and dispose in secured sanitary landfill

E DISPOSAL - Material is not classed as a hazardous waste

- Ministry of Environment waste class 252L' if disposing of in liquid form.

UST BOND

OT INFORMATION

Hazardous Material Proper Shipping Name	not applic.
Hazardous Class	not applic.
Identification Number	not applic.

HILE THE INFORMATION AND RECOMMENDATIONS SET FORTH ON THIS DATA SHEET RE BELIEVED TO BE ACCURATE AS OF THE PRESENT DATE, DA-LEE DUST CONTROL AKES NO WARRANTY WITH RESPECT THERETO AND DISCLAIMS ALL LIABILITY ROM RELIANCE THEREON.

REPARED BY

Donna Didtrek
Administration
Da-Lee Dust Control
P.O. Box 14
Fruitland, Ont
L0R 1L0 (416) 643-1135

March 10, 1989

APPENDIX E.7

Line Wash Oil

REVIEW PARAMETER LIST FOR LINE WASH OIL

A. GENERAL INFORMATION

High grade base stock oils produced by Ontario petroleum refineries are used as "line flush" or "line wash" oils, to clean out process lines after completed production runs. These line wash oils may also be used for dust suppression.

The following line wash oils were identified:

Dark Journal Oil (Petro Canada) - This is a double hydro treated base stock with various additives, yellow to amber in colour. It is a blend of many once through line wash oils. It is normally used in plain and antifriction bearings where lubrication is used for a short time.

COC-22 (Esso) - This is a solvent treated paraffinic base stock that has passed through the process lines more than once. It is dark brown in colour, and contains various additives. It is normally used in large lubricating systems and leaky hydraulic system for a short service life.

Faxam 22 (Esso) - Faxam 22 is not used as a line wash oil, but is included here because it is the same base stock as COC-22. It contains prescribed anti-rust and anti-oxidant additives so that it can be sold as a lubrication oil and hydraulic oil in large leaky systems.

Information on Dark Journal Oil from Petro Canada, as a representative line wash oil, was compiled for this review parameter list.

SUPPLIER/DISTRIBUTER INFORMATION

Manufactures and Distributors

Petro Canada Inc. (Dark Journal Oil)
5140 Yonge Street, Suite 200
North York, Ontario
M2N 6L6

Telephone: (416) 730-2000
Contact: Glen Moore

Esso Petroleum Canada (COC-22 and Faxam-22)
55 St. Clair Avenue West
Toronto, Ontario
M5W 2J8

Telephone: (416) 498-2470
Contact: Charles Schwarztel

Other petroleum refineries in Ontario may also produce line wash oil. Line wash oils are distributed by the oil company.

Applicators/Contractors

Two applicators of oil products in Ontario were identified during the study. The contact people for each manufacturer can also be contacted for other applicators.

The address for these two contractors are:

Da-Lee Dust Control
350 Jones Road
P.O. Box 14
Fruitland, Ontario
L0R 1L0

Telephone: (416) 643-1135
Contact: Donna Ditrek

NorJohn Ltd.
P.O. Box 100
Thorold, Ontario
L2V 3Y8

Telephone: (416) 336-1216
Contact: Dave Bratley

COST INFORMATION

Costs of line wash oils form Petro-Canada and Esso are in the range of $0.28 to $0.40 per litre (1991).

The applied cost of oil includes pick-up from the manufacturer, transportation to the site and application. Costs are in the range of $0.38 per litre to $0.50 per litre depending on the distance from the contractor to the site. At average suggested application

rates of 1.3 L/m^2 and at $0.38 per litre, final 1991 seasonal costs to the user are approximately $0.51 per square meter per season assuming only one application per season.

SAFETY PROCEDURES

Personal Protection

The following procedures will ensure the safe handling of the line wash oils.

1. Operators should wear chemical goggles if splashing of oil is likely or a high-pressure system is in use.

2. Operators should wear Neoprene or Nitrile gloves under normal use if contact is likely.

3. Operators are not required to wear respiratory protection under normal operations. Operators should wear approved organic vapour respirators suitable for oil mist in areas with sufficient oxygen if mist is generated by heating or spraying.

4. Operators should wear long sleeved clothing to minimize skin contact.

Emergency First Aid

First aid procedures are listed in the attached Material Safety Data Sheet for Dark Journal Oil.

Storage Requirements

Line wash oils should be stored in cool, well ventilated areas. Contact with strong oxidizing agents such as peroxides, chlorine, etc., must be avoided since these will react with oil.

Transportation and Shipping Requirements

No special precautions other than those normally employed in the transportation of industrial hydrocarbon liquids are necessary.

Spill Procedures

In accordance with Part 9, Section 79 of the Environment Protection Act, a spill is defined as any discharge, intentional or unintentional, of material from its containing unit beyond the recommended maximum application rate, into the natural environment. This can be caused by spray bars left on after operation, tank rupture, tank turn over, etc. In the event of a spill the following procedures are recommended:

1. The spill should be contained using sand or earth to prevent line wash oils from entering water ways or low areas. All sources of ignition must be removed.

2. As much as possible of the spilled oil should be recovered with pumping equipment or absorbent material.

3. The remaining spilled oil should be absorbed with sand, or diatomaceous earth or commercial solvents.

4. The following should be contacted:

    - All local municipal authorities.
    - The Spills Action Centre, at 1-800-268-6060.
    - Environment Canada at The Ontario Regional Environmental Emergencies line: (416)-973-1059, or (416)-346-1971 (cellular).
    - The applicator.

Source Description and Quality Control

Dark Journal Oil from Petro Canada is a blend of various line washings. Base stock oils are hydro treated twice and blended with various additives, such as anti-wear, rust inhibitors, dispersants, detergents etc., depending on the designed service for the oil. At the beginning of each production run the process lines are flushed , or washed, with the next grade of oil to be produced. Once the lines have been flushed, the new oil grade is produced. However, the oil used in the "flushing" is sent to a storage tank. Subsequent "flushings" are sent to the same tank. The stored line flushing, which contains a host of additives, is Petro Canada's Dark Journal Oil.

Imperial Oil's COC-22 is a light base stock paraffinic oil that is solvent treated and cold treated to remove aromatics and waxes. After normal production runs for various oils, COC-22 is flushed through the process lines to purge, or wash, them prior to the next process runs. A batch of COC-22 may be used several times to purge a system, and may contain a host of additives.

Faxam-22 is a straight base oil that is produced in a similar manner to COC-22 except that it is designed as a saleable oil for lubrication, etc. It contains prescribed anti-rust and anti-oxidant additives, and is not used as a line flush oil. In addition, Faxam 22 is not normally used as a dust suppressant, but may be used as such since it is similar to COC-22 in the base oil stock.

Quality Control

Oil quality for Dark Journal Oil and COC-22 is graded according to density, viscosity, pour point, boiling point range and other physical parameters. Since these are line flush oils, strict quality control is not enforced. Faxam-22 is also measured for the above parameters plus additive levels. All other quality control measures are proprietary.

B. TECHNICAL EFFECTIVENESS AND APPLICATION PROCEDURE

TECHNICAL EFFECTIVENESS

No specific literature on the technical effectiveness of line wash oil was identified in the information search. However, it is believed that all virgin oil products are generally as effective in controlling dust and stabilizing roads as waste oil previously used in Ontario. Thus, literature on the technical effectiveness of used oil is applicable to virgin oil performance. Oil controls dust primarily by soaking into the surface, wetting and agglomerating the aggregate particles and preventing them from becoming airborne by the natural cohesive nature of the oil. To evaluate the technical effectiveness of line wash oil, a literature review and a telephone survey of current and past users of virgin and waste oil in Ontario, were conducted.

The results of the telephone survey indicated that within Ontario, virgin oils are used primarily within industrial yards using heavy equipment, or on unusual surfaces, such as in horse arenas that combine sand and woodchips, to control dust. The experience of these users indicates that oil is the only effective means of controlling dust when cost, effective lifetime, and level of dust control are considered.

As with all dust suppressants, their technical effectiveness and lifetime are affected by weather, traffic load and surface composition.

The results of the telephone survey conducted for this study indicated rainfall did not reduce the dust suppressing abilities of virgin or used oils used on roads as noticeably as with other dust suppressants such as calcium chloride, lignosulphonates, etc. Users suggested that oil resists leaching and runoff more than other types of suppressants. However, very rainy conditions do have a tendency to make oil treated surfaces slippery, and may also promote potholing of municipal roads.

A Canada wide survey conducted by the British Columbia Ministry of the Environment (British Columbia, 1981) solicited mailed responses from various road agencies across Canada to find alternative dust suppressants to used oil. The results showed that oil was preferred in wet climates because longer periods of effective dust suppression resulted for oil treated roads compared to roads treated with other suppressants.

Traffic density and vehicle weights are variables in the effectiveness of oil in controlling dust emissions from roads and yards. The results of a survey of 15 Canadian and 2 U.S. highway agencies (Public Works Canada, 1983) showed that oil is the most popular road stabilizer and dust suppressant in areas with heavy truck traffic or high volume traffic. The telephone survey confirmed that industrial sites using heavy trucks, front end loaders, forklifts etc. also use virgin oil to suppress dust. No other dust suppressant is reported as effective for the same length of time as oil products. However, the effectiveness of the oil is reduced when sharp turns and stops from trucks abrade the surface. This action also promotes potholing.

The overall effectiveness of oil products over other chemicals was shown in a study carried out for the Ontario Ministry of the Environment (Acres, 1988). This study compared the technical effectiveness of used oil and industrial oil against other dust suppressants used on municipal roads in Southern Ontario. No surface aggregate compositions or application rates were reported. Dust emitted from the treated road surface over a three month period was measured at various sites, where a number of dust suppressants had been applied. Results indicated that the oil applications provided the best dust control over all other dust suppressants tested. Dust measurements taken from a moving vehicle travelling over the treated surface also indicated that dust emissions from the oil treated surfaces were the lowest of all suppressants tested.

In general, Ontario users have found that oil is the only suppressant that provides an acceptable level of dust suppression in sandy soils or open gravel (i.e. gravel with very little fines), or in areas with little or no moisture in the surface. However, a report on road surface treatments in Alaska (State of Alaska, 1982) indicated that the presence of large amounts of fines, particularly clays, can promote the absorption of petroleum based palliatives into the surface particles, which would reduce the binding effects of the dust palliative and the natural cohesive nature of the fines. This would result in soft spots in the surface and eventual potholing.

Summary of Overall Effectiveness

The performance of virgin oils is affected by several factors, including:

1. Oil products resist leaching and runoff resulting from precipitation to a greater extent than other dust suppressants.

2. Oil has been shown to have a longer effective period over other dust suppressants in wet climates compared to other dust suppressants.

3. Oil is a superior dust suppressant in areas that have heavy weight or high volume traffic, compared to other dust suppressants.

4. Oil has been shown to provide the highest level of dust control over other dust suppressants in under a range of conditions.

5. Oil is better suited as a road treatment for sandy surfaces, and dry open gravel surfaces, where other dust suppressants may not be as effective.

6. Oil applications may promote potholing on road surfaces with high fines and/or clay content.

APPLICATION PROCEDURES

Site Restrictions

According to the Ontario Ministry of Environment's Draft Guidelines for the Application of Dust Suppressants, product dust suppressants should not be applied to sites closely adjacent to or crossing waterway(s) or marshes, or near wells.

Surface Preparation

Published literature prescribing road preparation procedures for the application of oils were not identified in the information search. Preparation information was obtained from the telephone survey of Ontario municipalities and the contractors who apply virgin oil.

Surface preparation usually consists of no more than grading to remove potholes and corrugations. A general preparation for the road surface is as follows:

1. Proper drainage should be provided on both sides of the road.

2. The surface should be graded to a significant depth (20 to 50 mm) to remove pot holes, corrugations and other ruts. If the road is deeply rutted or corrugated it may require scarification between 25 and 100 mm.

3. Gravel or fines should be added as required to yield a final composition of up to 8 percent fines (<200 mesh).

4. Oils should be applied at desired levels while the surface still retains some moisture (this aids in wetting of the particle surfaces and helps prevent dust pockets from forming).

5. Compaction of the surface is suggested to provide a firm solid base, particularly if the surface is being newly constructed.

Application Equipment

Application equipment for virgin oils is usually a bituminous distributor. The Ontario Ministry of Transportation requires that the distributor be equipped with a pump capable of delivering a constant uniform pressure in the spray bar manifold. In addition, the spray bar must be capable of application over a variety of widths. The distributor tank should also come equipped with a dip stick for measuring quantities applied.

A general equipment list for bituminous distributors includes the following features:

- Recirculation in the tank.
- A quick opening gate in the dome.
- An external readily visible tank gauge.
- Rear mounted spray bars and nozzles 0.6 to 3.6 m wide capable of:
  - vertical and lateral adjustment
  - producing double coverage in one pass.
- Spray bars that do not extend into the lane of opposing traffic unless adequate warning measures are taken.
- The feed to the spray bars equipped with:
  - recirculation before and during operation and
  - filters.
- Spray nozzles:
  - fitted with instant on/off valves and
  - which yield fan-shaped sprays without atomization.
- A pressure pump capable of supplying approximately 726 L/min of oil.
- An operator visible 345 MPa pressure gauge.
- An operator visible flow meter.

- An operator visible pump tachometer.

Personnel Requirements

Typically two to four people are required for safe application of dust suppressants. This would consist of at least one, maybe two, flag-persons and/or an operator of a warning pilot vehicle, the operator of the application truck, and an application checker (the flag person can double as a checker).

Length of Time Before and After Precipitation

Application of oils should be made no sooner than 6 to 12 hours after a significant rainfall, but while the soil still retains some moisture. This will prevent dust beads from forming, which would prevent wetting of the soil aggregate by the oil. In addition, application should not be made within 6 hours of expected rainfall to permit complete saturation, penetration, and absorption of the oil into the road surface, and to prevent it from leaching and running off.

Dilution

Line wash oils are not diluted for application. Oils should not be mixed with anything other than other virgin hydrocarbon base oils for the purpose of thinning. Strong oxidizing agents should be particularly avoided.

Application Frequency and Rate

Virgin oils are usually applied once per season in Ontario at both municipal road and industrial sites (CH2M HILL, 1991). Some very heavy industrial locations may apply twice per season. According to a survey of various highway agencies in Canada and the U.S. (Public Works Canada, 1983), application of oil products ranges from two light applications per year of about 0.8 to 1.7 L/m^2 to one heavy application in Alberta of about 2.5 to 3.0 L/m^2 every two to three years. Ontario industrial application rates vary from 0.3 L/m^2 to 1.9 L/m^2, and municipal application rates are from 1.1 to 1.3 L/m^2. Subsequent applications, if made, are at the same rates as initial applications.

Ponding should be avoided during application. Ponding will depend on several factors: the rate of oil discharge, the speed of the application truck, and the porosity of the surface materials. Ponding can be prevented by shutting off the spray bars when the vehicle/truck is stopped or is passing over paved/sealed portions of the road. Care should also be exercised to ensure that the oil is applied at or below the suggested rates. If ponding still occurs, then a decrease in the application rate is recommended.

Curing Time

There is no curing time associated with the line wash oils. They remain in the viscous liquid state. Traffic can be permitted immediately following application, but 1/2 hour of slowed traffic is recommended to permit adequate penetration.

Problems and Hazards

Driving over freshly applied oil may cause splashing onto cars. Heavy rains on roads with high clay content treated with oil may cause slippery conditions (the oil acts as a lubricant between clay particles).

C. PHYSICAL AND CHEMICAL CHARACTERISTICS

Dark Journal Oil from Petro Canada was used as a representative line wash oil for the purpose of defining physical and chemical characteristics.

PHYSICAL PROPERTIES

The physical characteristics of Dark Journal Oil from Petro Canada are presented below in Table 1.

Table 1
Physical Properties of Dark Journal Oil

Odour	Hydrocarbon
Appearance and colour before application	Yellow to dark amber
Physical state when applied	Viscous liquid
Physical state when dried	Viscous liquid
Solubility in water	Negligible
Vapour pressure @ 25% C	<0.01 kPa
Thermodynamic reaction with water	Neutral
Flammability/flash point	>195 °C
Auto Ignition Temperature	>250 °C
Boiling point	350 to 640 °C
Density (@15 °C)	900 kg/m^3
Percent Volatile (@20 °C)	0%

Source: Dark Journal Oil Material Safety Data Sheet (Petro Canada)

COMPOSITION AND CHEMICAL PROPERTIES

Dark Journal Oil is composed of the following main components:

- Severely treated paraffinic and solvent refined naphthenic oils (90 to 95 percent).
- Additives, including viscosity index improver, defoamer, rust inhibitor, antioxidant, pour point depressant, organic-zinc additive (5 to 10 percent).

A sample of Dark Journal Oil was provided by Petro Canada Ltd. for this study. The sample was split in the laboratory for duplicate analyses of conventional parameters, metals, polynuclear aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs). Analyses were carried out at CANVIRO Analytical Laboratories Ltd. Average results for the duplicate analyses are presented in Table 2.

The chemical components of Dark Journal Oil include one heavy metal (boron at 5 mg/L) and VOCs (chloroform, methyl ethyl ketone, carbon tetrachloride, benzene, ethylbenzene, m&p xylenes and toluene). VOCs were present at levels less than 800 µg/L. None of the PAH compounds were detected.

D. ACUTE TOXICITY AND SUB-LETHAL EFFECTS

ACUTE TOXICITY

B.A.R. Environmental conducted duplicate acute toxicity tests on Dark Journal Oil, using the sample provided by Petro Canada for this study. Since the oil is immiscible in water, normal toxicity testing procedures could not be followed. Therefore, the test measured the lethal effects of water to which 10,000 mg/L of oil had been added, and the combination aged for various lengths of time. The test species were rainbow trout and Daphnia magna. Table 3 presents the tests results.

The test results showed that as the aging period increased in length, the water became more toxic. Thus, with a concentration of 10,000 mg of oil in 1 L of water, aged for 96 hours prior to testing, a 20 percent mortality of rainbow trout (96h LC20) and Daphnia magna (48h LC20) resulted.

Additional Acute Toxicity Information

In acute toxicity tests, line wash oil is essentially non-toxic to animals. The LD50 to rats was found to be greater than 5 g/kg (Dark Journal Oil MSDS, 1990).

Table 2
Chemical Characteristics of Line Wash Oil[1]

	Units	Concentration
Conventional Parameters		
pH	mg/L	5.2
Total solids	mg/L	690,000
Ammonium Nitrogen	mg/L	<500
Metals		
Aluminum	mg/L	<2
Boron	mg/L	5
Barium	mg/L	<2
Beryllium	mg/L	<0.5
Cadmium	mg/L	<0.2
Calcium	mg/L	<5
Chromium	mg/L	<0.5
Cobalt	mg/L	<0.5
Copper	mg/L	<0.5
Iron	mg/L	<0.5
Lead	mg/L	<1
Magnesium	mg/L	<5
Manganese	mg/L	<0.5
Vanadium	mg/L	<0.5
Zinc	mg/L	2
Nickel	mg/L	3
Silver	mg/L	<0.5
Strontium	mg/L	<0.5
Sodium	mg/L	30
Arsenic	mg/L	<0.2
Selenium	mg/L	<0.2
Mercury	mg/L	<0.02
Polynuclear Aromatic Hydrocarbons		
Naphthalene	µg/L	<6.4
Acenaphthylene	µg/L	<6.4
Acenaphthene	µg/L	<12.8
Fluorene	µg/L	<6.4
Phenanthrene	µg/L	<11.2
Anthracene	µg/L	<12.8
Fluoranthene	µg/L	<9.6
Pyrene	µg/L	<6.4
Benzo (a) anthracene	µg/L	<8.0
Chrysene	µg/L	<11.2
Benzo (b) fluoranthene	µg/L	<11.2
Benzo (k) fluoranthene	µg/L	<11.2
Benzo (a) pyrene	µg/L	<9.6
Indeno (1,2,3-cd) pyrene	µg/L	<17.6
Dibenzo (a,h) anthracene	µg/L	<12.8
Benzo (ghi) perylene	µg/L	<14.4

Table 2
Chemical Characteristics of Line Wash Oil[1]

	Units	Concentration
Volatile Organic Compounds		
Horomethane	µg/L	<360
Vinyl Chloride	µg/L	<500
Bromomethane	µg/L	<200
Chloroethane	µg/L	<160
Trichlorofluoromethane	µg/L	<350
Acrolein	µg/L	<220
1,1-Dichloroethylene	µg/L	<160
Methylene Chloride	µg/L	<180
Acrylonitrile	µg/L	<210
trans,1,2-Dichloroethylene	µg/L	<70
1,1-Dichloroethane	µg/L	<50
Methyl ethyl ketone	µg/L	750
Chloroform	µg/L	182
Bromochloromethane	µg/L	<20
1,1,1-Trichloroethane	µg/L	<50
Carbon tetrachloride	µg/L	180
1,2-Dichloroethane	µg/L	<30
Benzene	µg/L	65
Trichloroethylene	µg/L	<190
1,2-Dichloropropane	µg/L	<20
Bromodichloromethane	µg/L	<20
2-Chloroethylvinyl ether	µg/L	<40
trans-1,3-Dichloropropylene	µg/L	<30
cis-1,3-Dichloropropylene	µg/L	<50
Toluene	µg/L	155
1,1,2-Trichloroethane	µg/L	<30
Tetrachloroethylene	µg/L	<80
Dibromochloromethane	µg/L	<20
Ethylene dibromide	µg/L	<60
Chlorobenzene	µg/L	<20
m&p Xylene	µg/L	98
Ethyl benzene	µg/L	32
Styrene	µg/L	<40
o-Xylene	µg/L	<40
Bromoform	µg/L	<30
1,1,2,2-Tetrachloroethane	µg/L	<50
1,3-Dichlorobenzene	µg/L	<20
1,4-Dichlorobenzene	µg/L	<10
1,2-Dichlorobenzene	µg/L	<40

Notes:

1. Average of duplicate analysis sample of Dark Journal Oil from Petro Canada.
< Below detection limit.

Table 3
Acute Toxicity of Dark Journal Oil

Test Species	Test Solution Aging Period Prior to Test (h)	Length of Time Organism Was Exposed to Aged Test Solutions (h)	Effect on Organism	Concentration (mg/L)	95 Percent Confidence Interval (mg/L)
Rainbow Trout	24 96	96 96	non-lethal 20% mortality	10,000 10,000	NA NA
Daphnia magna	24 96	48 48	non-lethal 20% mortality	10,000 10,000	NA NA

Notes:

NA: Not applicable.

SUB-LETHAL EFFECTS

Limited information is available on the sub-lethal effects of line wash oil. To assess the potential sublethal effects of line wash oil, individual chemical components present in Dark Journal Oil at concentrations above guidelines and standards for drinking water and/or aquatic life, as presented in Table 4, were examined.

Table 4
Comparison of Contaminant Limits for Drinking Water and Aquatic Life to Concentrations in Dark Journal Oil[1]

Parameter	Aquatic Life	Drinking Water	
Methyl ethyl ketone (µg/L)	n/a	n/a	750
Carbon tetrachloride (µg/L)	13[4]	5[3]	180

Notes:

1. Only parameters with concentrations exceeding referenced limits are presented.
2. Ontario Ministry of the Environment, 1984. Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.
3. Health and Welfare Canada, 1987. Canadian Guidelines for Drinking Water Quality.
4. Environment Canada & Health and Welfare Canada, 1991. How Safe is our Water?
5. E.P.A. Cited from W.H.O. literature.
6. Cited from Ontario Ministry of the Environment literature.

Comparing the concentrations of toxic substances in 100 percent strength of the dust suppressant product provides an indication of toxicity to human and aquatic life only on a "worst case" basis. Some dilution effects will occur once the material is released to land and exposed to the effects of runoff, leaching and degradation. In addition, concentration of persistent substances after repeated application may also occur. The

exact extent of dilution or build-up will depend largely on site specific factors and will not be addressed in generic assessments of sub-lethal effects.

In the absence of a detailed exposure and risk assessment, it is not possible to completely assess the degree of human or environmental health risk passed by the posed by Dark Journal Oil. The following discussion attempts only to identify the contaminants of concern which could potentially cause problems over the long term. In many cases, the toxological data available is limited.

Main Components

Line wash oil has a low oral toxicity and has a laxative effect on ingestion. Repeated exposure may cause local irritation of the mouth, throat, oesophagus and stomach (Dark Journal Oil MSDS, 1990).

Repeated or prolonged contact of line wash oil on the skin may cause irritation and possibly dermatitis, mainly due to its volatile hydrocarbon components (Dark Journal Oil MSDS, 1990). Slight dermal absorption would occur, but it would not be of significance.

Inhalation of its mist may cause chemical pneumonitis and central nervous system depression. This is due to its volatile components (Dark Journal Oil MSDS, 1990).

Contaminant Based Assessment

Only two volatile organic carbon compounds were measured in Dark Journal Oil at levels exceeding relevant guidelines for drinking water quality or aquatic life. Guideline levels incorporate significant safety factors and are based on long term exposure. In addition, VOC levels will reduce rapidly at the application site through evaporation. Therefore, there are not likely to be human and environmental health concerns associated with VOCs in Dark Journal Oil.

SUMMARY

The following main points summarize the acute toxicity and sub-lethal effect of Dark Journal Oil:

- Dark Journal Oil, aged at a concentration of 10,000 mg/L for 96 hours was non-lethal to rainbow trout (96h) or Daphnia magna (46h).
- Dark Journal Oil is essentially non-lethal, as measured in rats (LD50 >5,000 g/kg).

- Dark Journal Oil may cause eye and skin irritation on contact, and mist inhalation may cause chemical pneumonitis and central nervous system depression.

E. ENVIRONMENTAL IMPACTS

MAIN DUST SUPPRESSANT COMPONENTS

No literature sources describing field studies of the environmental impacts of line wash oil as a dust suppressant were identified.

Dark Journal Oil is one hundred percent lubricating oil. Although its movement through the environment has not been evaluated, it can be described in general terms. The oil is for the most part, immiscible and has a higher viscosity than water, and therefore, migration will not be affected by water movement. Oil will migrate from the application site by leaching and penetrating into soil, and will be slowed by soil adsorption. Some components of the oil will solubilize in passing waters and leach away. Lighter fractions of the oil will volatilize, although the portion and rate of volatilization has not been determined. The entire product is biodegradable, and lighter fractions will biodegrade in the environment more quickly. The overall rate of decay in the environment has not been determined. In soil, the Ontario MOE's guidelines for site clean-up recommend that oil and grease levels should not exceed 1 percent by weight.

Analysis of BOD and phosphorus were not possible since the product is largely immiscible. Apart from acute toxicity effects, line wash oil floats on water and will create negative aesthetic impacts, including slicks and sheens.

COMPONENT-BASED ASSESSMENT

Since line wash oil is not marketed as a dust suppressant, no field studies have been conducted regarding its environmental impacts in this application. Examination of the individual components of the product provide the "next best" assessment of environmental fate. The analytical results of this study presented in Table 2 were compared to relevant guidelines for soil presented in Table 5. Only a few VOC compounds slightly exceeded these guidelines.

Because these compounds were at levels not significantly different than soil clean-up levels, and since their volatile properties will result in their rapid evaporation from the application site, they would not have significant environmental impacts.

Table 5
Comparison of Contaminant Limits in Soil to Levels in Dark Journal Oil[1]

Parameter	Soil Concentrations	Dark Journal Oil
Methyl ethyl ketone	n/a	750 µg/L
Chloroform	100 µg/kg[2]	182 µg/L
Carbon tetrachloride	100 µg/kg[2]	180 µg/L
Benzene	50 µg/kg[2]	65 µg/L
Toluene	100 µg/kg[2]	155 µg/L

Notes:

1. Only parameters with concentrations exceeding referenced levels are presented.
2. Canadian Council of Ministers of the Environment, 1991. CCME Environmental Quality Criteria for Contaminated Sites, Final Draft. These values are interim assessment criteria and are to be considered background or recommended detection limit values.

SUMMARY

No field studies of the environmental impacts of line wash oil as a dust suppressant were identified. The oil will degrade in the environment, but floats and causes slicks and sheens on surface waters as a result of spills. Because levels of VOCs only slightly exceeded soil clean-up levels, and volatilization from the application site would be rapid, significant environmental impacts are not projected as a result of these compounds. Other contaminants measured in Dark Journal Oil were not at levels exceeding relevant background or site clean-up levels for soils.

MATERIAL SAFETY DATA SHEET

WHMIS CLASSIFICATION

Not Controlled

PRODUCT CODE: 490- 464, 472

DATE: February 15, 1991

SECTION I MATERIAL IDENTIFICATION

Trade Name:	DARK JOURNAL OIL S, E
Other Names:	None
Chemical Synonyms and Family:	Petroleum Hydrocarbon
Name of Manufacturer/Supplier Address & Emergency Phone Number:	Petro-Canada Inc. (403) 296-3000 P.O. Box 2844, Petro-Canada Centre Calgary, Alberta T2P 3E3
Poison Control Centre Numbers:	Consult local telephone directory for emergency numbers.
Application:	Dark Journal Oils are process oils used as 'once-through' lubricating oils for use in plain and antifriction bearings where lubricant is used for a short time.

SECTION II TRANSPORTATION

UN Number: NR Primary Classification: NR Subsiduary Classification: NR

Compatibility Groups: NR CANUTEC Transport Emergency No. (613) 996-6666

SECTION III COMPOSITION

COMPONENTS	ALLOWABLE LIMITS (8 HR.)	% (VOL.)	CAS #
Severely hydrotreated paraffinic and solvent refined heavy naphthenic oils. (C_{20} - C_{66})	5 mg/m^3 (oil mist)	90-95	72623-86-0 72623-84-8 72623-87-1 72623-85-9 64741-96-4
Viscosity index improver defoamer, rust inhibitor, antioxidant, pour point depressant, organo-zinc additive*	N/A	5-10	N/A

* Contains zinc dialkyldithiophosphate (<0.07 % as Zn)

NR-Not Regulated N/A-Not Applicable U-Unknown Cette fiche est aussi disponible en francais

Trade Name: DARK JOURNAL OIL S, E

SECTION IV — PHYSICAL DATA

Density: (@15°C)	0..84 to 0.89 kg/L (approx.)	Boiling Point/Range: (@ 1 atm)	>316 °C (approx.)
Vapour Pressure: (@ 25°C)	<0.001 kPa	Percent Volatile: (@ 20°C)	0%
Vapour Density: (@ 20°C)	N/A	Evaporation Rate:	N/A
Solubility in Water:	Negligible		
Viscosity (Kinematic): @ 40°C	20-160 cSt		
Pour Point:	30 to 43°C	Appearance: & Odour	Yellow to dark amber viscous liquid with hydrocarbon odour.

SECTION V — FIRE & EXPLOSION DATA

Flash Point (method used- COC):	> 195°C
Flammable limits in air (% by volume):	Unknown
Auto-Ignition Temperature:	> 235°C
Fire and Explosion Hazards: LOW FIRE HAZARD	Addition of water or foam may cause frothing. Do not cut, drill or weld empty containers.
Extinguishing Media:	Dry chemical or carbon dioxide for small fires. Water spray or foam for large fires.
Fire Fighting Procedures:	Contain spill. Cover with extinguishing agent. Use water spray to cool fire-exposed containers and as a protective screen. Do not point solid water stream directly into burning oil to avoid spreading. Wear self-contained breathing apparatus when fighting in confined areas.

SECTION VI — HEALTH HAZARD INFORMATION

Toxicity Data	*Estimated acute LD_{50} > 5000 mg/kg (rat, oral): practically non-toxic. Severely hydrotreated and propane-deasphalted residual oils are negative when tested by the modified Ames test.
Effects of Overexposure	
Inhalation:	If sprayed or misted may cause chemical pneumonitis.
Skin and Eyes:	Mildly irritate to eyes. Prolonged or repeated contact with skin may cause irritation and possibly dermatitis.
Ingestion:	Low toxicity on ingestion. Has laxative effect.

* Based on toxicity of severely hydrotreated paraffinic oil only.

Trade Name: DARK JOURNAL OIL S, E

Emergency and First Aid Procedures Information

Skin: Remove contaminated clothing - launder before reuse. Soap and water wash. Discard saturated leather articles.

Eyes: Copious warm water flush - 15 minutes. Physician assessment if eyes inflamed.

Inhalation: Evacuate to fresh air. Apply Cardio Pulmonary Resuscitation if required. Administer oxygen if available. If resuscitation is required, physician assessment is mandatory.

Ingestion: DO NOT INDUCE VOMITING. Force fluids. Activated charcoal tablets.

Notes to Physician Gastric lavage should only be done after endotracheal intubation in view of the risk of aspiration which can cause serious chemical pneumonitis for which antibiotic and corticosteroid therapy may be indicated.

SECTION VII — REACTIVITY DATA

Stability:	Stable.
Conditions to avoid:	Excessive heat, formation of oil mist.
Materials to avoid:	Strong oxidizing agents (peroxides, chlorine, strong acids, etc.).
Hazardous Decomposition products:	COx, SOx, oxides of zinc, phosphorus and calcium, smoke on combustion.
Can hazardous polymerization occur?:	No.

SECTION VIII — SPILL OR LEAK PROCEDURES

Steps to be taken if material is released or spilled:	Contain spill. Absorb with inert absorbent such as dry clay, sand or diatomaceous earth, commercial sorbents, or recover using pumps. Scoop up used absorbent and rags into drums.
Waste Disposal Method:	Dispose in approved, SECURE landfill site or licensed waste reclaimer facility.

SECTION IX SPECIAL PROTECTION INFORMATION

Ventilation:	General ventilation.
Respiratory Protection:	Normally not necessary. If mist generated by heating, spraying, etc. wear approved organic vapour respirator suitable for oil mist in areas with sufficient oxygen.
Protective Gloves:	For direct contact with hydrocarbons of more than two hours, NITRILE or VITON recommended. Otherwise, PVC gloves may be worn.
Eye Protection:	None normally required; chemical goggles if splashing likely or high-pressure systems used.
Other Protective Clothing:	Wear long sleeved clothing to minimize skin contact.

SECTION X SPECIAL PRECAUTIONS

Store in cool, well-ventilated area. Wash hands after handling and before eating. Avoid inhalation and skin contact. Launder work clothes frequently. Discard saturated leather goods.

SECTION XI REFERENCES

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NIOSH. The Industrial Environment - Its Evaluation and Control, 1973.
Petro-Canada Inc., Petro-Canada Report on Modified Ames Tests of Petroleum Basestocks, 1986.

Petro-Canada and its affiliates assume no responsibility for injury to anyone caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Additionally, Petro-Canada Inc. and its affiliates assume no responsibility for injury to anyone caused by abnormal use of the material even if reasonable safety procedures are followed. Furthermore, vendee and third persons assume the risk in their use of the material.

Petro-Canada Inc.

APPENDIX E.8

Coke Wash Oil

REVIEW PARAMETER LIST FOR COKE WASH OIL

A. GENERAL INFORMATION

Coke wash oil is manufactured by several Ontario petroleum refineries. The information in this report has been based on Petro Canada's Wash Oil A.

Coke wash oil from Petro Canada, known as Wash Oil A is a virgin, light fraction of hydro treated crude oil that is clear in colour and has a slight hydrocarbon odour. It contains no additives, metals, nitrogen or sulphur compounds. It is normally used for washing coke in the refinery process, spraying coke piles in the iron and steel industry for dust suppression, absorbing coke oven gases, dedusting potash, and defoaming paper pulp. It is also used for dust suppression of road and yard surfaces, and shoulders. The manufacturing process may differ slightly at other oil companies who manufacture coke wash oil.

SUPPLIER/DISTRIBUTER INFORMATION

Manufacturer and Supplier

Coke wash oil is manufactured and supplied by the oil company. Other petroleum refineries may also be contacted for information.

Petro Canada Inc.
5140 Yonge Street
Suite 200
North York, Ontario
M2N 6L6

Telephone: (416) 730-2000
Contact: Mr. Glen Moore

Applicators/Contractors

Petro Canada identified only one contractor in Ontario who applies Wash Oil A. This contractor is:

NorJohn Ltd.
P.O. Box 100
Thorold, Ontario
L2V 3Y8

Telephone: (416) 356-7222
Contact: Mr. Dave Bratley

Other contractors in Ontario may apply coke wash oil.

COST INFORMATION

Product costs are approximately $0.30/L (1991) delivered from the manufacturer to the applicator.

The contractor's costs to deliver the product to the site are usually included in the application costs, and vary proportionately to the distance travelled from the contractor.

Applied costs for Wash Oil A from Norjohn Ltd. are estimated at $0.39/L (1991). For recommended application rates between 1.1 L/m^2 to 1.5 L/m^2, and with one application per season, 1991 costs ranged from $0.43 to $0.60 (1991) per square meter per season.

SAFETY PROCEDURES

Personal Protection

The following protective measures suggested by Petro Canada will minimize the risk of personal injury when handling Wash Oil A.

1. Operators should wear chemical goggles if splashing of oil is likely or a high-pressure system is in use.

2. Operators should wear PVC gloves under normal use if contact is likely. If prolonged contact of 2 or more hours is likely, then VITON or NITRILE gloves are recommended.

3. Operators are not required to wear respiratory protection under normal operations. Operators should wear approved organic vapour respirators suitable for oil mist in areas with sufficient oxygen if mist is generated by heating or spraying.

4. Operators should wear long sleeved clothing to minimize skin contact.

Emergency First Aid

Emergency first aid treatment is outlined in the attached Material Safety Data Sheet for Wash Oil A.

Storage Requirements

Coke wash oil should be stored in cool, well ventilated areas. Contact with strong oxidizing agents such as peroxides, chlorine etc. must be avoided since these will react with oil.

Transportation and Shipping Requirements

No special precautions, other than those normally employed in the transportation of industrial hydrocarbon liquids, are necessary.

Spill Procedures

In accordance with Part 9, Section 79 of the Environment Protection Act, a spill is defined as any discharge, intentional or unintentional, of material from its containing unit beyond the recommended maximum application rate into the natural environment. This can be caused by spray bars left on after operation, tank rupture, tank over turn, etc. In the event of a spill the following procedures are recommended by Petro Canada for Wash Oil A:

1. The spill should be contained using sand or earth to prevent from entering water courses or low areas. All sources of ignition must be removed.

2. As much as possible of the oil should be recovered with pumping equipment or absorbent material.

3. The remaining spilled oil should be absorbed with sand, diatomaceous earth, or commercial sorbets.

4. The following should be contacted:

    - All local municipal authorities.
    - The MOE's Spills Action Centre, at 1-800-268-6060.
    - Environment Canada at The Ontario Regional Environmental Emergencies line: (416)-973-1059, or (416)-346-1971 (cellular).
    - The applicator.

SOURCE DESCRIPTION AND QUALITY CONTROL

Wash Oil A is derived from paraffinic oil that has been severely hydro treated at temperatures of 400 °C and at a pressure of 20,700 kPa. Wash Oil A is the light fraction that is obtained from vacuum distillations of the lube fraction. No details on procedures for quality control were provided by Petro Canada.

B. TECHNICAL EFFECTIVENESS AND APPLICATION PROCEDURES

TECHNICAL EFFECTIVENESS

Specific literature on the technical effectiveness of coke wash oil in general, or Wash Oil A specifically, was not identified. However, it is believed that all virgin oil products behave similarly to used oil as a dust suppressant and road stabilizer. Thus, literature on the technical effectiveness of used oil is applicable to virgin oil performance. Oil controls dust primarily by soaking into the surface, wetting and agglomerating the aggregate particles and preventing them from becoming airborne by the natural cohesive nature of the oil. To summarize the technical effectiveness of coke wash oil, both a literature survey, and a telephone survey of current and past users of virgin and used oil in Ontario, were conducted as part of this study.

The results of the telephone survey indicated that within Ontario, virgin oils are used primarily within industrial yards using heavy equipment, or on unusual surfaces, such as in horse arenas that combine sand and woodchips, to control dust. The experience of these users indicates that oil is the only effective means of controlling dust when cost, effective lifetime, and level of dust control are considered.

As with all dust suppressants, the technical effectiveness and lifetime are affected by weather, traffic load and surface composition.

The results of the telephone survey conducted for this study indicated that the performance waste oil and virgin oil was not as negatively affected by rainfall as with other dust suppressants such as calcium chloride, lignosulphonates, etc. Users also reported that oil resists leaching and runoff more than salt or lignosulphonates. However, very rainy conditions did have a tendency to make treated surfaces slippery compared to untreated surfaces. Rain also promoted potholing of municipal roads treated with used or virgin oil.

A Canada wide survey conducted by the British Columbia Ministry of the Environment (British Columbia, 1981) solicited mailed responses from various road agencies across Canada to find alternative dust suppressants for used oil. The results showed that oil was preferred in wet climates because it demonstrated dust control effectiveness over longer periods compared to other palliatives.

Traffic density and vehicle weight are also variables in the effectiveness of virgin oil. The results of a survey of 15 Canadian and 2 U.S. highway agencies (Public Works Canada, 1983) showed that oil is the most popular road stabilizer and dust suppressant in areas with heavy truck traffic or high volume traffic. The CH2M HILL telephone survey confirmed that industrial sites using heavy trucks, front end loaders, forklifts etc. use virgin oil to suppress dust. No other dust suppressant was reported to be as effective for the same length of time as oil products. However, the effectiveness of the oil is reduced when sharp turns and stops by trucks wear the surface. This action also promotes potholing.

The overall effectiveness of oil products over other dust suppressants was also shown in a study carried out for the Ontario Ministry of the Environment (Acres, 1988). This study compared the technical effectiveness of used oil and industrial oil against other dust suppressants used on municipal roads in Southern Ontario. No surface aggregate compositions or application rates were reported. Dust emitted from treated road surfaces measured over a three month period indicated that the oil applications provided the best dust control over the other dust suppressants tested. Dust measurements taken from a moving vehicle travelling over the treated surface, also indicated that dust emissions from surfaces treated with oils were the lowest of all suppressants tested.

In general, Ontario users have found that oil is the only suppressant that provides an acceptable level of dust suppression in sandy soils, or open gravel (i.e. gravel with very little, fines) or in areas with little or no surface moisture. However, a report on road surface treatments in Alaska (State of Alaska, 1982) indicated that the presence of large amounts of fines, particularly clays, can promote the absorption of petroleum based palliatives into the particles, which would reduce the binding effects of the oil and the natural cohesive nature of the fines. This would result in soft spots in the surface and eventual potholes.

Summary of Overall Effectiveness

The performance of virgin oils is affected by several factors summarized below:

1. Oil products may resist leaching and runoff resulting from precipitation to a greater extent than other dust suppressants.

2. Oil has been shown to have a longer effective dust suppression period in wet climates compared to other dust suppressants.

3. Oil is a superior dust suppressant in areas that have heavy weight or high volume traffic because of its effectiveness and lifetime compared to the performance of other dust suppressants.

4. Oil has been shown to provide the highest level of dust control over other dust suppressants in several areas.

5. Oil is better suited as a road treatment for surfaces that are sandy or contain dry open gravel, where other dust suppressants may not be as effective.

6. Oil may promote potholing on surfaces with high fines and clay content.

APPLICATION PROCEDURES

Site Restrictions

According to the Ontario Ministry of Environment's Draft Guidelines for the Application of Dust Suppressant, dust suppressants should not be applied to sites closely adjacent to or crossing waterway(s) or marshes, or near wells.

Preparation

No published literature was identified which prescribes road preparation procedures for the application of virgin oil. Preparation information was obtained from a survey conducted for this study with Ontario municipalities and the contractors who apply virgin oil.

Surface preparation usually consists of no more than grading to remove potholes and corrugations. A general preparation of the road surface for dust suppressant application is as follows:

1. Proper drainage should be provided on both sides of the road.

2. The surface should be graded to a significant depth (20 to 50 mm) to remove pot holes, corrugations and other ruts. If the road is deeply rutted or corrugated it may require scarification between 25 and 100 mm.

3. Gravel or fines should be added as required to yield a final composition of up to 8 percent fines (<200 mesh).

4. Virgin oil should be applied at desired levels while the surface still retains some moisture (this aids in wetting of the particle surfaces and helps prevent dust pockets from forming).

5. Compaction of the surface is suggested to provide a firm solid base, particularly if the surface is being newly constructed.

Length of Time Before and After Precipitation

Application of oils should be made no sooner than 6 to 12 hours after a significant rainfall, but while the soil still retains some moisture. This will prevent dust beads from forming, which prevent wetting of the soil aggregate by the oil. In addition, application should not be made within 6 hours of expected rainfall to permit complete saturation, penetration, and sorption of the oil into the road surface. If heavy rains are expected, oil should not be applied until afterward to prevent leaching and runoff.

Application Equipment

Application equipment for virgin oils is usually a bituminous distributor. The Ontario Ministry of Transportation requires that the distributor be equipped with a pump capable of developing a constant uniform pressure in the spray bar manifold. In addition, the spray bar must be capable of application over a variety of widths. The distributor tank should also come equipped with a dip stick for measuring quantities applied.

A general equipment list for bituminous distributors includes the following items:

- Recirculation in the tank.
- A quick opening gate in the dome.
- An external readily visible tank gauge.
- Rear mounted spray bars and nozzles 0.6 to 3.6 m wide capable of:
  - vertical and lateral adjustment
  - producing double coverage in one pass.
- Spray bars that do not extend into the lane of opposing traffic unless adequate warning measures are taken.
- The feed to the spray bars equipped with:
  - recirculation before and during operation
  - filters.
- Spray nozzles:
  - fitted with instant on/off valves, and,
  - which yield fan-shaped sprays without atomization.
- A pressure pump capable of supplying approximately 726 L/min of oil.
- An operator visible 345 MPa pressure gauge.

- An operator visible flow meter.
- An operator visible pump tachometer.

Personnel Requirements

Typically two to four people are required for safe application of dust suppressants This would consist of at least one, maybe two, flag-persons and/or an operator of a warning pilot vehicle, the operator of the application truck, and an application checke (the flag person can double as a checker).

Dilution/Mixing Restrictions

Wash Oil A is not normally diluted for application. Virgin oils should not be mixed with anything other than other virgin hydrocarbon base oils for the purpose of thinning Strong oxidizing agents should be particularly avoided.

Application Frequency and Rate

Virgin oils are usually applied once per season for both municipal road and industria site locations. Some very heavy industrial locations may require a second applicatio per season. According to a survey of various highway agencies in Canada and the U.S (Public Works Canada, 1983), application of oil products ranges from two light applica tions per year of about 0.8 to 1.7 L/m^2 to one heavy application of about 2.5 to 3.0 L/m^2 every two to three years. Ontario industrial application rates vary from 0.3 L/m to 1.9 L/m^2, and municipal application rates reported are from 1.1 to 1.3 L/m^2. Subse quent applications, if made, are at the same rates as initial applications.

Ponding should be avoided during application. Ponding will depend on several factors the rate of oil discharge, the speed of the application truck, and the porosity of the surface materials. Ponding can be prevented by shutting off the spray bars when the vehicle/truck is stopped or is passing over paved/sealed portions of the road. Care should also be exercised to ensure that the oil is applied at or below the suggested rates. If ponding still occurs, then a decrease in the application rate is necessary.

Curing Time

There is no curing time associated with Wash Oil A. It remains in the viscous liquid state. Traffic can be permitted on immediately following application, but 1/2 hour o slowed traffic is recommended to permit adequate penetration.

Problems and Hazards

Driving over freshly applied oil may cause splashing onto cars. Heavy rains on high clay content roads treated with oil may cause slippery conditions (the oil acts as a lubricant between clay particles).

C. PHYSICAL AND CHEMICAL PROPERTIES

The following is a summary of physical and chemical properties of Wash Oil A. Wash Oil A from Petro Canada was tested as a representative of coke wash oil in Ontario, since it is known to be applied as a road dust suppressant.

PHYSICAL PROPERTIES

The physical characteristics of Wash Oil A are presented in Table 1.

Table 1
Physical Properties of Wash Oil A

Property	Description
Odour	Hydrocarbon odour
Appearance and colour before application	Clear, colourless to light yellow
Physical state when applied	Viscous liquid
Physical state when dried	Viscous liquid
Density	0.87 kg/L
Solubility in water	Negligible
Vapour pressure (@ 25 ^{o}C)	<0.01 kPa
Flammability/flash point	137 ^{o}C
Boiling point (@ 1 atm)	285 - 350 ^{o}C
Pour point	-24 ^{o}C
Viscosity (@ 40 ^{oC})	4 - 7 cSt at 40 ^{o}C

Source: Petro Canada Wash Oil A Material Safety Data Sheet, 1991.

COMPOSITION AND CHEMICAL PROPERTIES

Wash Oil A is a 100 percent complex mixture of aromatic/aliphatic hydrocarbons.

A sample of Wash Oil A was provided by Petro Canada. This sample was split in the laboratory, and duplicate analyses were carried out on chemical properties defined by conventional parameters, metals, volatile organic compounds (VOCs), and polynuclear aromatic hydrocarbons (PAHs). CANVIRO Analytical Laboratories Ltd. carried out all analyses. Duplicate sample results were averaged and are presented in Tables 2.

Table 2
Chemical Characteristics for Petro Canada Wash Oil A[1]

	Units	Concentration
Conventional Parameters		
pH	mg/L	7.8
Total solids	mg/L	562,000
BOD_5	mg/L	NA
Ammonium Nitrogen	mg/L	<500
Total Phosphorus	mg/L	30.8
Metals		
Aluminum	mg/L	<2
Boron	mg/L	5.5
Barium	mg/L	<2
Beryllium	mg/L	<0.5
Cadmium	mg/L	<0.2
Calcium	mg/L	<5
Chromium	mg/L	<0.5
Cobalt	mg/L	<0.5
Copper	mg/L	<0.5
Iron	mg/L	<0.5
Lead	mg/L	<1
Magnesium	mg/L	2
Manganese	mg/L	<0.5
Vanadium	mg/L	<0.5
Zinc	mg/L	<1
Nickel	mg/L	<0.5
Silver	mg/L	<0.5
Strontium	mg/L	<0.5
Sodium	mg/L	10
Arsenic	mg/L	<0.2
Selenium	mg/L	<0.1
Mercury	mg/L	<0.02
Polynuclear Aromatic Hydrocarbons		
Naphthalene	µg/L	1,710
Acenaphthylene	µg/L	<80
Acenaphthene	µg/L	38,500
Fluorene	µg/L	<80
Phenanthrene	µg/L	<140
Anthracene	µg/L	<160
Fluoranthene	µg/L	4,010
Pyrene	µg/L	6,140
Benzo (a) anthracene	µg/L	<100
Chrysene	µg/L	<140
Benzo (b) fluoranthene	µg/L	<140
Benzo (k) fluoranthene	µg/L	<140
Benzo (a) pyrene	µg/L	<140
Indeno (1,2,3-cd) pyrene	µg/L	<220
Dibenzo (a,h) anthracene	µg/L	<160
Benzo (ghi) perylene	µg/L	<180

Table 2 Chemical Characteristics for Petro Canada Wash Oil A[1]		
	Units	Concentration
Volatile Organic Compounds		
Chloromethane	µg/L	<360
Vinyl chloride	µg/L	<500
Bromomethane	µg/L	<200
Chloroethane	µg/L	<160
Trichlorofluoromethane	µg/L	<350
Acrolein	µg/L	<220
1,1-Dichloroethylene	µg/L	<160
Methylene chloride	µg/L	<180
Acrylonitrile	µg/L	<210
trans,1,2-Dichloroethylene	µg/L	<70
1,1-Dichloroethane	µg/L	<50
Methyl ethyl ketone	µg/L	<110
Chloroform	µg/L	<40
Bromochloromethane	µg/L	<20
1,1,1-Trichloroethane	µg/L	<50
Carbon tetrachloride	µg/L	<70
1,2-Dichloroethane	µg/L	<30
Benzene	µg/L	<40
Trichloroethylene	µg/L	<190
1,2-Dichloropropane	µg/L	<20
Bromodichloromethane	µg/L	<20
2-Chloroethylvinyl ether	µg/L	<40
trans-1,3-Dichloropropylene	µg/L	<30
cis-1,3-Dichloropropylene	µg/L	<50
Toluene	µg/L	<22.5
1,1,2-Trichloroethane	µg/L	<30
Tetrachloroethylene	µg/L	<80
Dibromochloromethane	µg/L	<20
Ethylene dibromide	µg/L	<60
Chlorobenzene	µg/L	<20
m&p Xylene	µg/L	39.5
Ethyl benzene	µg/L	15.0
Styrene	µg/L	<40
o-Xylene	µg/L	20.5
Bromoform	µg/L	<30
1,1,2,2-Tetrachloroethane	µg/L	<50
1,3-Dichlorobenzene	µg/L	<20
1,4-Dichlorobenzene	µg/L	<10
1,2-Dichlorobenzene	µg/L	<40

Notes:

1. Average of duplicate sample results for Wash Oil A from Petro Canada.
< Below detection limit.
NA Not analyzed.

D. ACUTE TOXICITY AND SUB-LETHAL EFFECTS

ACUTE TOXICITY

B.A.R. Environmental conducted acute toxicity tests on duplicate samples of Wash Oil A provided by Petro Canada on rainbow trout and Daphnia magna. The test measured

the lethal effects of 10,000 mg/L solutions aged for 24 and 96 hours. This is a sligh deviation from normal LC50 procedures since Wash Oil A will not dissolve in wate The toxicity test results therefore, represent the toxicity of the compounds that dis solved into the water after the specified aging period from the Wash Oil A.

When aged in solution for 24 h, coke wash oil caused 12.5 percent mortality t Daphnia magna at a concentration of 10,000 mg/L. When aged for 96 h, an LC50 o 6,4742 mg/L was estimated

When aged in solution for 24 h, coke wash oil caused 50 percent mortality in rainbo trout at a concentration of 10,000 mg/L. When aged for 96 h, an LC50 of 8,062 mg/ was determined.

According to one rating system (IMCO/FAO/UNESCO/WHO, 1969), Wash Oil A toxi city rates a Grade 0 on a scale 0 to 4, where 0 is the least toxic.

Table 3
Acute Toxicity of Wash Oil A

Organism	Test Solution Aging Period Prior to Use	Length of Time Organism Exposed to Aged Test Solution	Effect on Organism	Concentration (mg/L)	95 Percent Confidence Interval (mg/L)
Rainbow Trout	24	96	50% mortality	10,000	NA
	96	96	100% mortality	10,000	NA
	96	96	30% mortality	10,000	NA
	96	96	LC50[1]	8,062	6,500 - 10,000
Daphnia magna	24	48	12% mortality	10,000	NA
	96	48	LC50[1]	6,474	5,208 - 8,054

Notes.

1. Estimate based on mortality results.
NA Not applicable

SUBLETHAL EFFECTS

To assess, the sub-lethal effects of Wash Oil A, the effects of individual chemical com ponents present at concentrations above guidelines and standards for drinking wate and/or aquatic life, presented in Table 4, were reviewed.

Comparing the concentrations of toxic substances in 100 percent strength of the dus suppressant product provides an indication of toxicity to human and aquatic life only or a "worst case" basis. Some dilution effects will occur once the material is released t land and exposed to the effects of runoff, leaching and degradation. In addition, con centration of persistent substances after repeated application may also occur. The

exact extent of dilution or build-up will depend largely on site specific factors and will not be addressed in generic assessments of sub-lethal effects.

In the absence of a detailed exposure and risk assessment, it is not possible to completely assess the degree of human or environmental health risk posed by Wash Oil A. The following discussion attempts only to identify the contaminants of concern which could potentially cause problems over the long term. In many cases, the toxological data available is limited.

Table 4
Comparison of Contaminant Limits for Drinking Water and Aquatic Life to Concentrations in Coke Wash Oil[1]

Parameter	Aquatic Life	Drinking Water	Calcium Chloride (35% Solution)
Phosphorus (mg/L)	0.02[2]	N/A	30.8
Boron (µg/L)	N/A	5,000[2,3]	5,500
Fluoranthene (µg/L)	N/A	0.2 (total for 6 PAH)[4]	4,010
Naphthalene (µg/L)	N/A	N/A	1,710
Acenaphthene (µg/L)	N/A	N/A	38,500
Pyrene (µg/L)	N/A	N/A	6,140
m & p-xylene (µg/L)	N/A	30 (m-xylene)[3] 30 (p-xylene)[3]	39.5

Notes:

1. Only parameters with concentrations exceeding referenced limits are presented.
2. Ontario Ministry of the Environment, 1984. Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.
3. Health and Welfare Canada, 1987. Canadian Guidelines for Drinking Water Quality.
4. World Health Organization, 1984. Guidelines for Drinking Water Quality, Volume 2 Health Criteria and other supporting information.

Main Components

Short term inhalation of oil fumes from Wash Oil A may be irritating to the nose and throat. Vapours may cause chemical pneumonitis, and can also irritate the eyes. Prolonged or repeated contact with skin may cause irritation and possibly dermatitis. Ingestion may have a slight laxative effect. (Wash Oil A MSDS, 1991).

Component Based Assessment

PAH compounds found in Wash Oil A have been shown to have teratogenic, mutagenic and/or carcinogenic properties in animals and are probable human carcinogens.

However, the heavier PAH compounds, which are those of most concern, such as fluoranthene, are likely to remain closely associated with roadbed materials and are not very mobile. Therefore, contamination of drinking water, groundwater or surface is unlikely. Ingestion and inhalation of road dust, or mist during application, may be more likely routes of exposure. There are many natural and anthropogenic sources of PAH.

One metal, boron, and two volatile organic compounds, m & p-xylenes, were present at levels only slightly above relevant drinking water quality guidelines. Guidelines are based on lifetime consumption of 1.5 L of water per day, and incorporate significant safety factors. Thus, these compounds are insignificant with respect to human health concerns.

SUMMARY

The following points summarize the acute toxicity and sub-lethal effects associated with coke wash oil:

- Coke wash oil aged in water for 96 h is lethal to rainbow trout at an estimated concentration of 8,062 mg/L (96 h LC50) and to Daphnia magna at estimated concentration of 6,474 mg/L.

- Limited data indicate that coke wash oil may have human health effects related to nose and throat irritation when inhaled, eye irritation and damage, dermal effects on contact, and a range of effects if ingested.

- PAH contaminants in coke wash oil would not likely contaminate water supplies. However, exposure may occur through inhalation of oil mist during application, or road dust.

E. ENVIRONMENTAL IMPACTS

MAIN DUST SUPPRESSANT COMPONENTS

No literature sources describing field studies of the environmental impacts of coke wash oil and Wash Oil A as a dust suppressant were identified.

Wash Oil A is a one hundred percent complex mixture of aromatic/aliphatic hydrocarbons. Although its movement through the environment has not been evaluated, it can be described in general terms. The oil is for the most part, immiscible and has a higher viscosity than water, and therefore, migration will not be affected by water movement. Oil will migrate from the application site by leaching and penetrating into soil, and will be slowed by soil adsorption. Some components of the oil will solubilize in passing waters and leach away. Lighter fractions of the oil will volatilize, although the portion

and rate of volatilization has not been determined. The entire product is biodegradable, and lighter fractions will biodegrade in the environment more quickly. The overall rate of decay in the environment has not been determined. In soil, the Ontario MOE's guidelines for site clean-up recommend that oil and grease levels should not exceed 1 percent by weight.

Analysis of BOD and phosphorus were not possible since the product is largely immiscible. Apart from acute toxicity effects, coke wash oil floats on water and will create negative impacts, including slicks and sheens.

COMPONENT-BASED ASSESSMENT

Since coke wash oil is not marketed as a dust suppressant, no field studies have been conducted regarding its environmental impacts in this application. Examination of the individual components of the product provide the "next best" assessment of environmental fate. The analytical results of this study have been used to develop a short list of components which represent a range of possible fates for coke wash oil which is released to land.

Table 5 presents those contaminants in Wash Oil A that exceed guideline levels for soils.

Table 5
Comparison of Organic Contaminant Limits in Soil to Levels in Wash Oil A[1]

Parameter	Soil Concentrations	Coke Wash Oil
Naphthalene	100 µg/kg (dry wt.)[2]	1,710 µg/L
Acenaphthene	N/A	38,500 µg/L
Fluoranthene	N/A	4,010 µg/L
Pyrene	100 µg/kg (dry wt.)[2]	6,140 µg/L

Notes:

1. Only parameters with concentrations exceeding referenced levels are presented.
2. Canadian Council of Ministries of the Environment, 1991. Interim CCME Environmental Quality Criteria for Contaminated Sites, Final Draft. These values are interim assessment criteria and are to be considered background or recommended detection limit values.

Organic Compounds

In order to assess a range of the persistence and migration characteristics of coke wash oil, a number of the components from the list in Table 5 have been selected for further discussion.

For assessment of environmental impacts of the PAH compounds, two compounds were selected for further discussion to represent the range of possible environmental fates for this group of compounds. Naphthalene is the lightest molecule in the group, pyrene, a middle weight molecule, but the heaviest one detected in Wash Oil A.

For organic contaminants, environmental fate and behaviour can be at least partially predicted through a knowledge of physical/chemical properties such as those presented in Table 6 for the selected organic components.

Table 6
Physical/Chemical Properties of Selected Components of Coke Wash Oil[1]

Component	Component Group	Molecular Weight (g/g-mole)	Vapour Pressure (mm Hg at 25 °C)	Aqueous Solubility (mg/L at 25 °C)	Log Octanol-Water Partition Coefficient	Henry's Law Constant (atm-m^3/g-mole at 25°C)
Naphthalene	PAH	128.16	0.082	31.7	3.30	4.83×10^{-4}
Pyrene[2]	PAH	202	6.85×10^{-7} at 20°C	0.14	5.32	-

Notes:

1. Data taken from Howard (1989 and 1990) except as noted.
2. Data taken from U.S. EPA (1979).

It is difficult to assess the combined effects of all the properties noted in Table 6 based solely on a review of the data. The Fugacity Level I model has been used as a means to achieve a measure of the combined effects of these properties. Results for the chemicals of interest are reported in Table 7. It should be emphasized that this model does not consider which environmental compartments receive releases of the chemical, nor the rate at which equilibrium is achieved. Also not taken into consideration are degradation reactions which may deplete the amount of chemical in the model environment.

Table 7
Results of Level I Fugacity Modelling

Component	Percentage of Component in Each Environmental Compartment at Equilibrium			
	Bulk Air	Bulk Water	Bulk Soil	Bulk Sediment
Naphthalene	62.71	35.02	2.10	0.17
Pyrene	0.16	15.38	78.20	6.26

Since the Fugacity Level I model bases predictions of environmental fate solely on physical/chemical properties and considers only organic chemicals, the following discussions on each of the components of interest have been provided to summarize literature information on the relative importance of various fate mechanisms including:

- Evaporation
- Adsorption
- Degradation through biodegradation, photolysis, hydrolysis, etc.
- Migration in water

These discussions also attempt to describe the fate of releases to land since this is the scenario involved in the use of dust suppressants, as well as the movement of the chemical through the environment as equilibrium is approached.

Where available, information on concentrations of each of the components in various environmental media is also provided.

Naphthalene

Releases of naphthalene to land are moderately adsorbed by soil particles and also undergo biodegradation. Evaporation will be important only for naphthalene in the very near surface layer. Half-lives for biodegradation may be as short as a few hours to days if organisms have been previously acclimated, but as long as a few months if not. In water, volatilization, photolysis, sorption and biodegradation are all important fate mechanisms. In air, photochemically produced hydroxyl radicals rapidly react with naphthalene, as well as nitrates found in polluted urban night air Howard (1989 and 1990).

Natural sources of naphthalene include crude oil and any natural, uncontrolled combustion such as forest fire. Natural surface waters may contain up to 2 µg/L of naphthalene.

Pyrene

Pyrene is a polynuclear aromatic hydrocarbon consisting of four aromatic rings. Much of the information on its environmental fate and behaviour can be inferred from data on similar compounds. Releases of pyrene to land will bind strongly to soil particles of adequate organic carbon content and evaporation will not play a significant role in either short or long term fate. Although only sparingly soluble, leaching of pyrene to the ground water may occur over the long term, resulting in considerable persistence in the immediate vicinity of the release. In water, pyrene may be subject to photolysis and, to a lesser extent, oxidation. Biodegradation and biotransformation are also believed to play a role in the long term fate of pyrene (U.S. EPA, 1979).

Pyrene is present in the environment due to both natural and anthropogenic sources and has been detected in ambient river water.

Metals

None of the metal contaminants present in the Wash Oil A sample were at concentrations above the guidelines for soils. In a study for the Ontario Ministry of the Environment (Acres, 1988) metals were measured in road surface materials treated with waste crankcase oil and industrial waste oil, as well as in road ditches and vegetation near the treated site. Despite the fact that metal concentrations in both waste oils were higher than measured in the Wash Oil A sampled for this study, there was no indication that road oils, road site ditches and vegetation metals levels were higher than background levels as a result of oil applications. Thus, metals in waste oils were not considered to cause significant environmental impacts. However, long term build-up of metals after frequent applications has not been examined.

SUMMARY

The following main points summarize the environmental impacts of coke wash oil application for dust suppressions.

- Field studies have not been identified which examined the migration or persistence of coke wash oil in the environment.
- Oil is known to be biodegradable, and immiscible, although some solubli-zation of a fraction of oil will occur. The rate of biogredation, volatilization and migration will depend in several site specific factors, which have not been determined.
- Lighter PAHs such as naphthalene will be subject to both leaching and evaporation.
- Heavier PAH such as pyrene will persist at the application site for long periods of time, although some leaching and biodegradation will occur.
- Metals present in coke wash oils are not at concentrations considered to be environmentally significant.

MATERIAL SAFETY DATA SHEET

WHMIS CLASSIFICATION

Not Controlled

PRODUCT CODE: 490-345

DATE: February 15, 1991

SECTION I MATERIAL IDENTIFICATION

Trade Name:	WASH OIL A
Other Names:	None .
Chemical Synonyms and Family:	Petroleum hydrocarbon.
Name of Manufacturer/Supplier Address & Emergency Phone Number:	**Petro-Canada Inc. (403) 296-3000** **P.O. Box 2844, Petro-Canada Centre** **Calgary, Alberta T2P 3E3**
Poison Control Centre Numbers:	Consult local telephone directory for emergency numbers.
Application:	Wash Oil A is a process oil used for a variety of applications such as absorbing coke oven gases, dedusting potash, and defoaming paper pulp, etc.

SECTION II TRANSPORTATION

UN Number: NR Primary Classification: NR Subsiduary Classification: NR

Compatibility Groups: NR CANUTEC Transport Emergency No. (613) 996-6666

SECTION III COMPOSITION

COMPONENTS	ALLOWABLE LIMITS (8 HR.)	% (VOL.)	CAS #
Complex mixture of aromatic/aliphatic hydrocarbons* (C_{16} - C_{21})	5 mg/m^3 (oil mist)	100	64742-46-7

* Contains total aromatics 3.9% (benzene = nil).

NR-Not Regulated N/A-Not Applicable U-Unknown

Cette fiche est aussi disponible en français.

Trade Name: WASH OIL A

SECTION IV PHYSICAL DATA

ensity: (@ 15°C)	0.87 kg/L	Boiling Point/Range: (@ 1 atm)	285-350°C
Vapour Pressure: (@ 25°C)	< 0.01 kPa (estimated)	Percent Volatile: (@ 20°C)	0%
Vapour Density: (@ 20°C)	N/A	Evaporation Rate:	N/A
Solubility in Water:	Negligible		
Viscosity (Kinematic): (@ 40°C)	4.0-7.0 cSt (typical)		
Pour Point:	- 24°C	Appearance: & Odour	Colorless to light yellow viscous liquid with hydrocarbon odour.

SECTION V FIRE & EXPLOSION DATA

Flash Point (method used- COC):	125°C (minimum); 137°C (typical)
Flammable limits in air (% by volume):	N/A
Auto-Ignition Temperature:	235°C
Fire and Explosion Hazards: LOW FIRE HAZARD	Addition of water or foam may cause frothing. Do not cut, drill or weld empty containers.
Extinguishing Media:	Dry chemical or carbon dioxide for small fires. Water spray or foam for large fires.
Fire Fighting Procedures:	Contain spill. Cover with extinguishing agent. Use water spray to cool fire-exposed containers and as a protective screen. Do not point solid water stream directly into burning oil to avoid spreading.

SECTION VI HEALTH HAZARD INFORMATION

Toxicity Data	Wash Oil A is negative when tested by the modified Ames test.
Effects of Overexposure	
Inhalation:	If sprayed or misted may cause chemical pneumonitis.
Skin and Eyes:	Mildly irritating to eyes. Prolonged or repeated contact with skin may cause mild irritation and possibly dermatitis
Ingestion	Low toxicity on ingestion. Has laxative effect

Trade Name: WASH OIL A

Emergency and First Aid Procedures Information

Skin: Remove contaminated clothing - launder before reuse. Soap and water wash. Discard saturated leather articles.

Eyes: Copious warm water flush - 15 minutes. Physician assessment if eyes inflamed.

Inhalation: Evacuate to fresh air. Apply Cardio Pulmonary Resuscitation if required. Administer oxygen if available. If resuscitation is required, physician assessment mandatory.

Ingestion: DO NOT INDUCE VOMITING. Force fluids. Activated charcoal tablets.

Notes to Physician Gastric lavage should only be done after endotracheal intubation in view of the risk of aspiration which can cause serious chemical pneumonitis for which antibiotic and corticosteroid therapy may be indicated.

SECTION VII REACTIVITY DATA

Stability:	Stable.
Conditions to avoid:	Excessive heat, formation of oil mist.
Materials to avoid:	Strong oxidizing agents (peroxides, chlorine, strong acids, etc.).
Hazardous Decomposition products:	CO_x, smoke on combustion.
Can hazardous polymerization occur?:	No.

SECTION VIII SPILL OR LEAK PROCEDURES

Steps to be taken if material released or spilled:	Contain spill. Absorb with inert absorbent such as dry clay, sand or diatomaceous earth, commercial sorbents, or recover using pumps. Scoop up used absorbent into drums.
Waste Disposal Method:	Dispose in approved, SECURE landfill site or licensed waste reclaimer facility.

SECTION IX SPECIAL PROTECTION INFORMATION

Ventilation:	General ventilation.
Respiratory Protection:	Normally not necessary. If mist generated by heating, spraying, etc. wear approved organic vapour respirator suitable for oil mist in areas with sufficient oxygen.
Protective Gloves:	For direct contact with hydrocarbons of more than 2 hours.VITON or NITRILE recommended. Otherwise PVC gloves may be worn.
Eye Protection:	None normally required; chemical goggles if splashing likely or high-pressure system used.
Other Protective Clothing:	Wear long sleeved clothing to minimize skin contact.

SECTION X SPECIAL PRECAUTIONS

Store in cool, well-ventilated area. Wash hands after handling and before eating. Avoid inhalation and skin contact. Launder work clothes frequently. Discard saturated leather goods.

SECTION XI REFERENCES

ACGIH. Threshold Limit Values and Biological Exposure Indices for 1989-90.
CONCAWE. First Aid Measures, Medical Toxicology Data and Professional Advice to Clinicians on Petroleum Products, February 1983.
API. Petroleum Process Stream Terms Included in the Chemical Substances Inventory Under the Toxic Substances Control Act (TSCA), 1983.
NIOSH. The Industial Environment - Its Evaluation and Control. 1973.
Petro-Canada Inc., Petro-Canada Report on Modified Ames Tests of Petroleum Basestocks, 1986.

Petro-Canada and its affiliates assume no responsibility for injury to anyone caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Additionally, Petro-Canada Inc. and its affiliates assume no responsibility for injury to anyone caused by abnormal use of the material even if reasonable safety procedures are followed. Furthermore, vendee and third persons assume the risk in their use of the material.

Petro-Canada Inc.

APPENDIX E.9

Bunker Fuel Oil

REVIEW PARAMETER LIST FOR BUNKER FUEL OIL

A. GENERAL INFORMATION

Bunker fuel is available from most petroleum refineries in Ontario. However, at the time of this study, no Ontario companies were identified who supply bunker fuel as a dust suppressant. For the purposes of this study, a sample of bunker fuel oil was obtained from Petro Canada Inc., and therefore, specific information including toxicity and chemical characteristics are based on this sample.

Bunker fuel is a residual fuel that is normally burned as a fuel oil for heating purposes. It may contain asphaltines, cracked olefinic compounds and metals such as nickel, vanadium and cadmium. It is characterized as a black, very viscous liquid with a definite hydrocarbon smell accompanied by a slight rotten egg odour.

SUPPLIER/DISTRIBUTER INFORMATION

Manufacturers and Distributors

Petro Canada Inc.
5140 Yonge St.
Suite 200
North York, Ontario
M2N 6L6

Telephone: (416) 730-2000
Contact: Mr. Glen Moore

Esso Petroleum Canada
55 St. Clair Avenue West
Toronto, Ontario
M5W 2J8

Telephone: (416) 498-2470
Contact: Mr. Charles Schwartzel

Shell Canada Products Ltd.
Shell Place
75 Wynford Dr.
Don Mills, Ontario
M3C 2Z4

Telephone: (416) 443-7099
Contact: Mr. Kirt McNaughton

Bunker fuel oil may also be available from other Ontario petroleum companies.

Applicators/Contractors

At the time of this study, applicators who currently apply bunker fuel as a road dust suppressant were not identified. However, Keith Thompson Ltd. in Sudbury did apply bunker fuel mixed with diesel fuel as a dust suppressant over 15 years ago.

COST INFORMATION

Bunker fuel costs range from $0.06 to $0.10 per litre (1991) depending on the demand and the price of crude oil.

There is no information available on application cost, since current applicators were not identified.

SAFETY PROCEDURES

Personal Protection

The following protective measures will minimize the risk of personal injury when handling bunker fuel oil:

1. Operators should wear chemical goggles if splashing of oil is likely or a high-pressure system is in use.

2. Operators should wear PVC gloves under normal use if contact is likely. If prolonged contact of 2 or more hours is likely, then Viton or Nitrile gloves are recommended.

3. Operators are not required to wear respiratory protection under normal operations. Operators should wear approved organic vapour respirators suitable for oil mist in areas with sufficient oxygen, if mist is generated by heating or spraying.

4. Operators should wear long sleeved clothing to minimize skin contact.

Emergency First Aid

First aid procedures are outlined in the attached Material Safety Data Sheet for Heavy Fuel Oil (Petro Canada, 1990).

Storage Requirements

Bunker fuel oil should be stored in cool, well ventilated areas. Contact with strong oxidizing agents such as peroxides, chlorine etc. must be avoided since these will react with oil.

Transportation & Shipping

Transportation of bunker fuel for road oiling is generally made at elevated temperatures, near 60 °C, to maintain an acceptable viscosity for application spraying. No special precautions other than those necessary for transportation of heated industrial hydrocarbon products is required.

Spill Procedures

In accordance with Part 9, Section 79 of the Environment Protection Act, a spill is defined as any discharge, intentional or unintentional, of material from its containing unit beyond the recommended maximum application rate into the natural environment. This can be caused by spray bars left on after operation, tank rupture, tank over turn, etc. In the event of a spill the following procedures are recommended:

1. The spill should be contained using sand or earth to prevent oil entering water ways or low areas. All sources of ignition must be removed.

2. As much of the oil as possible should be recovered with pumping equipment or absorbent material.

3. The remaining spilled oil should be absorbed with sand, diatomaceous earth, or commercial solvents.

4. The following should be contacted:

    - All local municipal authorities,

    - MOE's Spills Action Centre, at 1-800-268-6060,

- Environment Canada at The Ontario Regional Environmental Emergencies line: (416)-973-1059, or (416)-346-1971 (cellular).

- The supplier and applicator of the oil.

SOURCE

Bunker fuel is a residual fuel found in the settled bottoms of emptied tankers, and tanks. It is a heavy component of the refinery process coming from the bottoms of vacuum distillation columns and catalytic crackers. It usually contains polynuclear aromatic hydrocarbons (PAHs) and is high in pitch and other components normally found in asphalt. It is sold as a low cost heating fuel. Critical specifications for bunker fuel are the viscosity (which is to be between 92 and 678 cSt at 50 °C), density, and gravity. Bunker fuels are blended with various lighter distillate fraction components to ensure the final properties. No other quality control parameters or steps are taken.

B. TECHNICAL EFFECTIVENESS AND APPLICATION PROCEDURES

TECHNICAL EFFECTIVENESS

Limited specific literature on the technical effectiveness of bunker fuel exists. It is believed that all virgin oil products are equally effective as waste oils for dust suppression. Oil controls dust primarily by soaking into the surface, wetting and agglomerating the aggregate particles and preventing them from becoming airborne by the natural cohesive nature of the oil. Thus, literature on the technical effectiveness of used oil is applicable to virgin oil performance. To summarize the technical effectiveness of bunker fuel, a literature survey, and a telephone survey of current and past users of virgin and used oil in Ontario were conducted as part of this study

According to Keith Thompson Ltd. (Keith Thompson Ltd., 1991), bunker fuel diluted with diesel fuel would not penetrate the road surface as deeply as other oil products. Rather, bunker fuel dries out and forms an oil crust on the surface. This reduces the gradability of the road for maintenance purposes. No other technical information on the effectiveness of bunker fuel specifically has been found.

The telephone survey of Ontario users found that, within Ontario, virgin oils are used widely within industrial yards using heavy equipment, and on unusual surfaces, such as in horse arenas that combine sand and woodchips, to control dust. The experience of these users indicates that oil is the only effective means of controlling dust when cost, effective lifetime, and level of dust control are considered.

As with all dust suppressants, the technical effectiveness and effective lifetime are affected by weather, traffic load and surface composition.

The results of the telephone survey conducted for this study indicated that rainfall did not reduce the dust suppressing abilities of virgin or used oils used on roads as noticeably as with other dust suppressants such as calcium chloride, lignosulphonates, etc. Users suggested that oil resists leaching and runoff more than other types of suppressants. However, very rainy conditions do have a tendency to make oil treated surfaces slippery, and may also promote potholing of municipal roads.

A Canada wide survey conducted by the British Columbia Ministry of the Environment (British Columbia, 1981) solicited mailed responses from various road agencies across Canada to find alternative dust suppressants to used oil. The results showed that oil was preferred in wet climates because longer periods of effective dust suppression resulted for oil treated roads compared to roads treated with other suppressants.

Traffic density and vehicle weights are variables in the effectiveness of oil in controlling dust emissions from roads and yards. The results of a survey of 15 Canadian and 2 U.S. highway agencies (Public Works Canada, 1983) showed that oil is the most popular road stabilizer and dust suppressant in areas with heavy truck traffic or high volume traffic. The telephone survey confirmed that industrial sites using heavy trucks, front end loaders, forklifts etc. also use virgin oil to suppress dust. No other dust suppressant is reported as effective for the same length of time as oil products. However, the effectiveness of the oil is reduced when sharp turns and stops from trucks wear the surface. This action also promotes potholing.

The overall effectiveness of oil products over other chemicals was shown in a study carried out for the Ontario Ministry of the Environment (Acres, 1988). This study compared the technical effectiveness of used oil and industrial oil against other dust suppressants used on municipal roads in Southern Ontario. No surface aggregate compositions or application rates were reported. Dust emitted from the treated road surface over a three month period was measured at various sites, where a number of dust suppressants had been applied. Results indicated that the oil applications provided the best dust control over all other dust suppressants tested. Dust measurements taken from a moving vehicle travelling over the treated surface also indicated that dust emissions from the oil treated surfaces were the lowest of all suppressants tested.

In general, Ontario users have found that oil is the only suppressant that provides an acceptable level of dust suppression in sandy soils or open gravel (i.e. gravel with very little fines), or in areas with little or no moisture in the surface. However, a report on road surface treatments in Alaska (State of Alaska, 1982) indicated that the presence of large amounts of fines, particularly clays, can promote the absorption of petroleum based palliatives into the surface particles, which would reduce the binding effects of the dust palliative and the natural cohesive nature of the fines. This would result in soft spots in the surface and eventual potholing.

Summary of Overall Effectiveness

The following points summarize the overall effectiveness of virgin oil as a dust suppressant:

1. Bunker fuel mixed with diesel fuel behaves similar to other oil products as a dust suppressant. However, it does not penetrate the road surface as deeply as other oils.

2. Oil products may resist leaching and runoff resulting from precipitation to a greater extent than other dust suppressants.

3. Oil has been shown to have a longer period of effectiveness in wet climates compared to other dust suppressants.

4. Oil is effective for longer periods of time over other dust suppressants in areas that have heavy weight or high volume traffic.

5. Oil has been shown to provide the highest level of dust control over other dust suppressants under a range of conditions.

6. Oil is better suited as a road treatment for sandy surfaces, and dry open gravel surfaces where other dust suppressants may not be as effective.

7. Oil applications may promote potholing on road surfaces with high fines and/or clay content.

APPLICATION PROCEDURES

Site Restrictions

According to the Ontario Ministry of Environment's Draft Guidelines for the Application of Dust Suppressants, dust suppressants should not be applied to sites closely adjacent to, or crossing, waterway(s) or marshes, or near wells.

Preparation

Published literature prescribing the road preparation procedures for the application of bunker fuel were not identified. Road preparation information was obtained from the telephone survey conducted for this study with municipalities and the contractors that use and apply virgin oils other than bunker fuel.

Surface preparation usually consists of no more than grading to remove potholes and corrugations. However, a general preparation for the road surface to ensure proper application is as follows:

1. Proper drainage should be provided on both sides of the road.

2. The surface should be graded to a significant depth (20 to 50 mm) to remove pot holes, corrugations and other ruts. If the road is deeply rutted or corrugated it may require scarification between 25 and 100 mm.

3. Gravel or fines should be added as required to yield a final composition of up to 8 percent fines (<200 mesh) (UMA Engineering Ltd., 1987).

4. Oil should be applied at desired levels while the surface still retains some moisture (this aids in wetting of the particle surfaces and helps prevent dust pockets from forming).

5. Compaction of the surface is suggested to provide a firm solid base, particularly if the surface is being newly constructed.

Application Equipment

Application equipment for virgin oils is usually a bituminous distributor. The Ontario Ministry of Transportation requires that the distributor be equipped with a pump capable of developing a constant uniform pressure in the spray bar manifold. In addition, the spray bar must be capable of application over a variety of widths. The distributor tank should also come equipped with a dip stick for measuring quantities applied.

A general equipment list for bituminous distributors contains the following:

- Recirculation in the tank.
- A quick opening gate in the dome.
- An external readily visible tank gauge.
- Rear mounted spray bars and nozzles 0.6 to 3.6 m wide capable of:
  - vertical and lateral adjustment
  - producing double coverage in one pass.
- Spray bars that do not extend into the lane of opposing traffic unless adequate warning measures are taken.

- The feed to the spray bars equipped with:
  - recirculation before and during operation
  - filters.

- Spray nozzles:
  - fitted with instant on/off valves, and,
  - which yield fan-shaped sprays without atomization.

- A pressure pump capable of supplying approximately 726 L/min of oil.

- An operator visible 345 MPa pressure gauge.

- An operator visible flow meter.

- An operator visible pump tachometer.

Personnel Requirements

Typically two to four people are required for safe application of dust suppressants. This would consists of at least one, maybe two, flag-persons and/or an operator of a warning pilot vehicle, the operator of the application truck, and an application checker (the flag person can double as a checker).

Length of Time Before and After Precipitation

Application of bunker fuel should be made no sooner than 6 to 12 hours after a significant rainfall, but while the soil still retains some moisture. This will prevent dust beads from forming, thereby prevent wetting of the soil aggregate by the oil. In addition, application should not be made within 6 hours of expected rainfall to permit complete saturation, penetration, and sorption of the oil into the road surface, and to prevent its leaching and running off.

Dilution

Bunker fuel used for road oiling has previously been mixed with diesel fuel at a 60 to 40, bunker fuel to diesel ratio. A final temperature of approximately 60 °C maintains a viscosity acceptable for spraying.

Virgin oils should not be mixed with anything other than other virgin hydrocarbon base oils for the purpose of thinning. Strong oxidizing agents should be avoided since these will react with oils.

Application Frequency and Rate

An application rate of bunker fuel is not available since current applicators of this product were not identified. However, virgin oils are usually applied once per season for both municipal road and industrial site locations. Some very heavy industrial locations may apply twice per season. According to a survey of various highway agencies in Canada and the U.S. (Public Works Canada, 1983), application of oil products ranges from two light applications per year, of about 0.8 to 1.7 L/m^2 to one heavy application in Alberta, of about 2.5 to 3.0 L/m^2 every two to three years. Ontario industrial application rates vary from 0.3 L/m^2 to 1.9 L/m^2, and municipal application rates are from 1.1 to 1.3 L/m^2. Subsequent applications, if made, are at the same rates as initial applications.

Ponding should be avoided during application. Ponding will depend on several factors: the rate of bunker fuel discharge, the speed of the application truck, and the porosity of the surface materials. Ponding can be prevented by shutting off the spray bars when the vehicle/truck is stopped or is passing over paved/sealed portions of the road. Care should also be exercised to ensure that the oil is applied at or below the suggested rates. If ponding still occurs, then a decrease in the application rate is necessary.

Curing Time

The curing time required for bunker fuel applications sufficient to evaporate the diesel fuel is about 24 hours.

Problems and Hazards

Driving over freshly applied oil may cause splashing onto cars. Heavy rains on high clay content roads treated with oil may cause slippery conditions (the oil acts as a lubricant between clay particles).

C. PHYSICAL AND CHEMICAL CHARACTERISTICS

PHYSICAL PROPERTIES

The physical characteristics of bunker fuel from Petro Canada are presented below in Table 1.

Table 1
Physical Properties of Bunker Fuel

Property	Bunker Fuel
Odour	Hydrocarbon/rotten egg
Appearance and colour before application	Black/viscous
Physical state when applied	Viscous liquid
Physical state when dried	Tar-like
Solubility in water	Negligible
Vapour pressure (@ 25 °C)	0.7 kPa
Flammability/flash point	62 °C
Density	0.99 - 1 kg/L
Viscosity	80 - 638 cSt at 50 °C

Source: Heavy Fuel Oil Material Safety Data Sheet from Petro Canada, 1990.

CHEMICAL COMPOSITION PROPERTIES

Bunker fuel oil is composed of the following main components:

- Complex mixture of aromatic/aliphatic hydrocarbons ($\geq$97%).
- Sulphur (3%).

Chemical components of bunker fuel were analyzed by CANVIRO Analytical Laboratories Ltd. in duplicate samples provided by Petro Canada. Analyses included conventional parameters, metals, volatile organic compounds (VOCs) and polynuclear aromatic hydrocarbons (PAH). The results are presented in Table 2.

Several metals, including aluminum. boron, iron, vanadium, zinc and nickel were present at the parts per million level. In addition, several PAH compounds were present in individual concentrations up to 465 mg/L, and VOCs in concentrations up to 202 mg/L.

D. ACUTE TOXICITY AND SUB-LETHAL EFFECTS

ACUTE TOXICITY

B.A.R. Environmental conducted duplicate acute toxicity tests on bunker fuel oil, using the sample provided by Petro Canada for this study. Since the oil is immiscible in water, normal toxicity testing procedures could not be followed. Therefore, the test measured the lethal effects of water to which 10.000 mg/L of oil had been added, and the combination aged for various lengths of time. The test species were rainbow trout and Daphnia magna. Table 3 presents the test results.

Table 2
Chemical Characteristics of Bunker Fuel[1]

	Units	Concentration
Conventional Parameters		
pH	mg/L	6.05
Total solids	mg/L	480,000
BOD_5	mg/L	(2)
Ammonium Nitrogen	mg/L	<500
Total Phosphorus	mg/L	NA
Metals		
Aluminum	mg/L	10
Boron	mg/L	12
Barium	mg/L	<2
Beryllium	mg/L	<0.5
Cadmium	mg/L	<0.2
Calcium	mg/L	10
Chromium	mg/L	<0.5
Cobalt	mg/L	<0.5
Copper	mg/L	<0.5
Iron	mg/L	4
Lead	mg/L	<1
Magnesium	mg/L	5
Manganese	mg/L	<0.5
Vanadium	mg/L	18
Zinc	mg/L	4.5
Nickel	mg/L	12.5
Silver	mg/L	<0.5
Strontium	mg/L	<0.5
Sodium	mg/L	50
Arsenic	mg/L	<0.2
Selenium	mg/L	<0.2
Mercury	mg/L	<0.02
Polynuclear Aromatic Hydrocarbons		
Naphthalene	µg/L	155,000
Acenaphthylene	µg/L	<6.4
Acenaphthene	µg/L	<12.8
Fluorene	µg/L	187,500
Phenanthrene	µg/L	465,000
Anthracene	µg/L	<12.8
Fluoranthene	µg/L	<9.6
Pyrene	µg/L	11,300
Benzo (a) anthracene	µg/L	<8.0
Chrysene	µg/L	<11.2
Benzo (b) fluoranthene	µg/L	<11.2
Benzo (k) fluoranthene	µg/L	<11.2
Benzo (a) pyrene	µg/L	<9.6
Indeno (1.2.3-cd) pyrene	µg/L	<17.6
Dibenzo (a.h) anthracene	µg/L	<12.8
Benzo (ghi) perylene	µg/L	<14.4

Table 2
Chemical Characteristics of Bunker Fuel[1]

	Units	Concentration
Volatile Organic Compounds		
Chloromethane	µg/L	<360
Vinyl Chloride	µg/L	<500
Bromomethane	µg/L	<200
Chloroethane	µg/L	<160
Trichlorofluoromethane	µg/L	<350
Acrolein	µg/L	<220
1,1-Dichloroethylene	µg/L	<160
Methylene Chloride	µg/L	<180
Acrylonitrile	µg/L	<210
trans-1,2-Dichloroethylene	µg/L	<70
1,1-Dichloroethane	µg/L	<50
Methyl ethyl ketone	µg/L	70,500
Chloroform	µg/L	9,200
Bromochloroethane	µg/L	<20
1,1,1-trichloroethane	µg/L	<50
Carbon tetrachloride	µg/L	<70
1,2-Dichloroethane	µg/L	<30
Benzene	µg/L	20,500
Trichloroethylene	µg/L	<190
1,2-Dichloroethane	µg/L	<20
Bromodichloromethane	µg/L	<20
2-Chloroethylvinyl ether	µg/L	<40
trans-1,3-Dichloropropylene	µg/L	<30
cis1,2-Dichloropropylene	µg/L	<50
Toluene	µg/L	<50
1,1,2-Trichloroethane	µg/L	102,850
Tetrachloroethylene	µg/L	<30
Dibromochloroemethane	µg/L	<80
Dibromochloromethane	µg/L	<20
Ethylene dibromide	µg/L	<60
Chlorbenzene	µg/L	<20
m&p Xylene	µg/L	202,250
Ethyl benzene	µg/L	47,350
Styrene	µg/L	<40
o-Xylene	µg/L	97,150
Bromoform	µg/L	<30
1,1,2,2-Tetrachloroethane	µg/L	<50
1,3-Dichlorobenzene	µg/L	<20
1,4-Dichlorobenzene	µg/L	<10
1,2-Dichlorobenzene	µg/L	<40

Notes

1 Average of duplicate sample results for Bunker Fuel provided by Petro Canada
< Below detection limit.

Table 3 Acute Toxicity of Bunker Fuel Oil					
Organism	Test Solution Aging Period Prior to Use (h)	Length of Time Organism was Exposed to Aged Test Solution (h)	Effect on Organism	Concentration (mg/L)	95 Percent Confidence Interval (mg/L)
Rainbow Trout	24 96	96 96	Non-Lethal Non-Lethal	10,000 10,000	NA NA
Daphnia magna	24 96	48 48	Non-Lethal Non-Lethal	10,000 10,000	NA NA
Notes: NA: Not Applicable					

The toxicity data indicated that 10,000 mg of bunker fuel in 1 L of water, aged for 24 and 96 hours, is not lethal to rainbow trout or Daphnia magna.

Additional Acute Toxicity Data

Petro Canada's bunker fuel oil indicated that the product is slightly toxic to animals. The LD50 to rats is greater than 4.6 g/kg. The rabbit dermal LD50 is greater than 5 g/kg (Petro Canada Heavy Fuel Oil MSDS, 1990).

SUB-LETHAL EFFECTS

Limited information is available on the sub-lethal effects of bunker fuel oil. To assess the potential sub-lethal effects of bunker fuel, each individual chemical component present at concentrations above guidelines and standards for drinking water and/or aquatic life as presented in Table 4, was examined.

Comparing the concentrations of toxic substances in 100 percent strength of the dust suppressant product provides an indication of toxicity to human and aquatic life only on a "worst case" basis. Some dilution effects will occur once the material is released to land and exposed to the effects of runoff, leaching and degradation. In addition, concentration of persistent substances after repeated application may also occur. The exact extent of dilution or build-up will depend largely on site specific factors and will not be addressed in generic assessments of sub-lethal effects.

In the absence of a detailed exposure and risk assessment, it is not possible to completely assess the degree of human or environmental health risk posed by bunker fuel. The following discussion attempts only to identify the contaminants of concern which

could potentially cause problems over the long term. In many cases, the toxological data available is limited.

Table 4
Comparison of Contaminant Limits for Drinking Water and Aquatic Life to Concentrations in Bunker Fuel[1]

Parameter	Aquatic Life	Drinking Water	Bunker Fuel
Aluminium (µg/L)	5-100[2,4]	200[5]	10,000
Boron (µg/L)	n/a	5,000[2,4]	12,000
Iron (µg/L)	300[2]	300[2,3]	4,000
Vanadium (µg/L)	n/a	n/a	18,000
Nickel (µg/L)	25[2], 25-150[4]	n/a	12,500
Naphthalene (µg/L)	n/a	n/a	155,000
Fluorene (µg/L)	n/a	n/a	187,500
Phenanthrene (µg/L)	n/a	n/a	465,000
Pyrene (µg/L)	n/a	n/a	11,300
Methyl ethyl ketone (µg/L)	n/a	n/a	70,500
Chloroform (µg/L)	2[4]	350[2], 5[6],70[7]	9,200
Benzene (µg/L)	300[4]	10[5], 5[3]	20,500
1,1,2-Trichloroethane (µg/L)	n/a	0.6[6]	102,850
m & p-Xylene (µg/L)	n/a	30[3] (m-xylene) 30[3] (p-xylene)	202,250
Ethylbenzene (µg/L)	700[4]	2.4[3]	47,350
o-xylene (µg/L)	n/a	30[3]	97,150

Notes:

1. Only parameters with concentrations exceeding referenced limits are presented.
2. Ontario Ministry of the Environment, 1984. Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.
3. Health and Welfare Canada, 1987. Canadian Guidelines for Drinking Water Quality.
4. Environment Canada & Health and Welfare Canada, 1991. How safe is our water?
5. World Health Organization, 1984. Guidelines for Drinking Water Quality, Volume 2 Health Criteria and other supporting information.
6. E.P.A. Cited from W.H.O. literature.
7. Cited from MOE literature.

Main Components

Short term high dose feeding with bunker fuel oil may cause local irritation of the mouth, throat, oesophagus and stomach followed by absorption and the systemic symptoms of hydrocarbon poisoning. Intensive long term exposure may cause kidney and liver damage and blood disorders as well as deleterious effects on the central nervous system (BP Bunker Fuel Oil MSDS, 1990).

Repeated or prolonged contact with bunker fuel oil may result in defatting, oil acne, redness, itching, inflammation, cracking and possible secondary infection. It may also cause allergic reaction in some individuals. Contact with heated material may cause thermal burns (BP Bunker Fuel Oil MSDS, 1990).

Ingestion of high doses of this product may cause gastrointestinal disturbances. Symptoms include irritation, nausea, vomiting and diarrhoea.

The possibility of aspiration of high viscosity petroleum products is very small. However, if aspirated repeatedly, it may result in neurological, hepatic, gastrointestinal, cardiovascular and renal disorders.

Although a carcinogenic effect has been shown in experimental animals, IARC has determined that there is inadequate evidence of the carcinogenicity of bunker fuel oil in humans.

Contaminant Based Assessment

PAH compounds found in Bunker Fuel Oil have been shown to have teratogenic, mutanogenic and/or carcinogenic properties in animals, and are probably human carcinogens. In addition, PAH may be bioconcentrated in fresh water invertebrates. However, the heavier PAH compounds, such as pyrene, which are those of most concern, are likely to remain closely associated with roadbed materials, and are not very mobile. Therefore, contamination of drinking water, groundwater or surface water is unlikely. Ingestion or inhalation of road dust, or mist during application, may be more likely routes of exposure. There are many natural and anthropogenic sources of PAH.

Volatile organic compounds found in bunker fuel, are known to be potentially toxic. Benzene, for example, is a known human carcinogen, while ethylbenzene, toluene and xylenes may also potentially cause adverse effects. However, given that most of these compounds will be rapidly lost to the atmosphere via evaporation after application, and that the oil would only be used once or twice per season, it is perhaps more likely that VOCs would be of concern to applicators as opposed to bystanders or property owners. In the case of industrial site applications, on-site worker exposure may be of concern.

Several metals (Al, B, Fe, and Ni) were present at levels significantly above relevant guidelines. These compounds might be of human or environmental concern if ingested in massive amounts, or chronic inhalation exposure to metal dusts were experienced. They are not dermally penetrated and therefore, do not pose safety or handling risks. Again, it is noted that levels of these metals in the oil would be diluted significantly when migrating to ground or surface waters. Toxic or sub-lethal effects on aquatic life will be unlikely if care is taken not to apply bunker fuel oil in the immediate vicinity of surface water. However, metals are extremely persistent, and some concern may arise over build-up of some of the metals in application areas or nearby surface waters as a result of long-term use of this dust suppressant.

SUMMARY

The following main points summarize the acute toxicity and sub-lethal effects of Bunker fuel oil:

- Bunker fuel oil, aged at a concentration of 10,000 mg/L for 96 hours, was non-lethal to rainbow trout and Daphnia magna.
- Bunker fuel oil is slightly toxic, as measured in rats (LD50 > 4.6 g/kg).
- Limited data are available on the sub-lethal effects of bunker fuel oil itself. There are both short-term and long-term feeding effects. Prolonged exposure may lead to dermal problems and skin cancer. Inhalation of mist may also result in neurological, hepatic, gastrointestinal, cardiovascular and renal disorder.
- PAH and VOC compounds in bunker fuel have potential adverse effects. Likely routes of exposure include inhalation of oil mist during application, or road dust.
- Metals present in bunker fuel oil would not likely pose a significant concern related to human or animal toxicity resulting from normal dust suppressant application.

E. ENVIRONMENTAL IMPACTS

MAIN DUST SUPPRESSANT COMPONENTS

No literature sources describing field studies of the environmental impacts of bunker fuel as a dust suppressant were identified.

Bunker fuel oil is a mixture of 97 percent aromatic/aliphatic hydrocarbons and 3 percent sulphur. Although its movement through the environment has not been evaluated, it can be described in general terms. The oil is for the most part, immiscible and has a higher viscosity than water, and therefore, migration will not be affected by water movement. Oil will migrate from the application site by leaching and penetrating into soil, and will be slowed by soil adsorption. Some components of the oil will solubilize in passing waters and leach away. Lighter fractions of the oil will volatilize, although the portion and rate of volatilization has not been determined. Nearly the entire product is biodegradable, and lighter fractions will biodegrade in the environment more quickly. The overall rate of decay in the environment has not been

determined. In soil, the Ontario MOE's guidelines for site clean-up recommend that oil and grease levels should not exceed 1 percent by weight.

Analyses of BOD and phosphorus were not possible because the product is largely immiscible. Apart from acute toxicity effects, bunker fuel oil floats on water and will create negative aesthetic impacts, including slicks and sheens.

CONTAMINANT-BASED ASSESSMENT

Since bunker fuel is not marketed as a dust suppressant, no field studies have been conducted regarding its environmental impacts in this application. Examination of the individual components of the product provide the "next best" assessment of environmental fate. The analytical results of this study have been used to develop a short list of components which represent a range of possible fates for bunker fuel which is released to land. This short list was derived from the range of components exceeding relevant soil levels, shown in Table 5.

Table 5
Comparison of Contaminant Limits in Soil to Levels in Bunker Fuel Oil[1]

Parameter	Soil Concentrations (µg/kg dry weight)	Bunker Fuel Oil (µg/L)
Naphthalene	100[2]	155,000
Fluorene	n/a	187,500
Phenanthrene	100[2]	465,000
Pyrene	100[2]	11,300
Methyl ethyl ketone	n/a	70,500
Chloroform	100[2]	9,200
Benzene	50[2]	20,500
1,1,2-Trichloroethane	n/a	102,850
m&p-Xylenes	100 (total xylenes)[2]	202,250
Ethyl benzene	100[2]	47,350
o-Xylene	100 (total xylenes)[2]	97,150

Notes:

1. Only parameters with concentrations exceeding referenced levels are presented.
2. Canadian Council of Ministers of the Environment, 1991. Interim CCME Environmental Quality Criteria for Contaminated Sites, Final Draft. These values are interim assessment criteria and are to be considered background or recommended detection limit values.

Organic Contaminants

In order to assess a range of the persistence and migration characteristics of bunker fuel, a number of the components have been selected for further discussion.

For assessment of environmental impacts of the PAH compounds exceeding guideline levels presented in Table 5, two compounds were selected for further discussion to represent the range of possible environmental fates for this group of compounds. Naphthalene is the lightest molecule in the group and pyrene, a middle weight compound, but the heaviest PAH compound detected.

Several volatile organic compounds were present in bunker fuel oil at concentrations exceeding guideline levels for soils, presented in Table 5. Chloroform, ethylbenzene and o-xylene were selected as representative volatile organic compounds.

For organic contaminants, environmental fate and behaviour can be at least partially predicted through a knowledge of physical/chemical properties such as those presented in Table 6 for the selected organic components.

Table 6
Physical/Chemical Properties of Selected Organic Components of Bunker Fuel[1]

Component	Component Group	Molecular Weight (g/g-mole)	Vapour Pressure (mm Hg at 25 °C)	Aqueous Solubility (mg/L at 25 °C)	Log Octanol-Water Partition Coefficient	Henry's Law Constant (atm-m^3/g-mole at 25°C)
Chloroform	VOC	119.39	246	7950	1.97	4.35×10^{-3}
Benzene	VOC	78.11	95.19	1791	2.13	5.43×10^{-3}
Ethylbenzene	VOC	106.16	9.53	161	3.15	8.44×10^{-3}
o - Xylene	VOC	106.16	6.6	175	3.12	5.1×10^{-3}
Naphthalene	PAH	128.16	0.082	31.7	3.30	4.83×10^{-4}
Pyrene[2]	PAH	202	6.85×10^{-7} at 20°C	0.14	5.32	-

Notes:

1 Data taken from Howard (1989 and 1990) except as noted.
2 Data taken from U.S. EPA (1979). Henry's Law Constant value not available.

It is difficult to assess the combined effects of all the properties noted in Table 6 based solely on a review of the data. The fugacity Level I model has been used to achieve a measure of the combined effects of these properties. Results for the chemicals of interest are reported in Table 7.

It should be emphasized that this model does not consider which environmental compartments receive releases of the chemical, nor the rate at which equilibrium is achieved. Also not taken into consideration are degradation reactions which may deplete the amount of chemical in the model environment.

Table 7
Results of Level I Fugacity Modelling

Component	Percentage of Component in Each Environmental Compartment at Equilibrium			
	Bulk Air	Bulk Water	Bulk Soil	Bulk Sediment
Chloroform	95.19	4.79	0.02	0.00
Benzene	95.69	4.29	0.02	0.00
Ethylbenzene	96.99	2.88	0.12	0.01
o-Xylene	95.37	4.44	0.18	0.01
Naphthalene	62.71	35.02	2.10	0.17
Pyrene	0.16	15.38	78.20	6.26

Since the Fugacity Level I model bases predictions of environmental fate solely on physical/chemical properties and considers only organic chemicals, the following paragraphs on each of the components of interest have been provided to summarize literature information on the relative importance of various fate mechanisms including:

- Evaporation
- Adsorption
- Degradation through biodegradation, photolysis, hydrolysis, etc.
- Migration in water

These paragraphs also attempt to describe the fate of releases to land since this is the scenario involved in the use of dust suppressants, as well as the movement of the chemical through the environment as equilibrium is approached.

Where available, information on concentrations of each of the components in various environmental media is also provided.

Chloroform

The fate of releases of chloroform to land and water will be primarily evaporation to the atmosphere owing to chloroform's extremely high vapour pressure. Chloroform in the atmosphere will be transported long distances and will react with hydroxyl radicals formed by photochemical reactions. The half-life for this reaction is a few months. Some chloroform from land releases will leach into ground water where it may reside for considerable periods of time. However, rapid evaporation from near-surface soils should occur. Biodegradation may be a significant process, but data on this subject are

somewhat conflicting. Adsorption to soil particles will not be significant, nor will it hydrolyse in water or soil under normal environmental conditions (Howard, 1990).

The only known natural source of chloroform is volatilization from plants. Chlorination of drinking water supplies leads to the formation of chloroform and other trihalomethanes. Levels averaging 35 µg/L have been detected in summer in Canada. Surface waters are generally less than 50 µg/L (Howard, 1990).

Benzene

Benzene is a highly volatile substance and releases to land will be subject to rapid evaporation at the surface. In the atmosphere, oxidation by photolytically produced hydroxyl radicals will occur with a half-life of approximately two weeks. The presence of nitrogen oxides and sulphur dioxides may accelerate the reaction to a half-life of less than one week. Products of such oxidation include phenol, nitrophenols and nitrobenzene. Any compound remaining in the soil will be extremely mobile since benzene does not absorb to soil particles to any significant degree, and may leach to the ground water. Biodegradation is most likely to occur in shallow, aerobic ground water or in the soil itself. In water, benzene evaporates quickly and photodegradation may become significant in the absence of biodegradation. Absorption to sediment and hydrolysis are not expected to be significant mechanisms for removal of benzene from water (Howard, 1990).

There are a few natural sources of benzene including volcanoes, forest fires and volatilization from plants. Public drinking water supplies are generally less than 0.2 µg/L, while surface waters are generally less than 10 µg/L (Howard, 1990).

Ethylbenzene

When released to land, some evaporation of ethylbenzene will occur, along with adsorption to soil particles and leaching to ground water. The latter process will be more significant in soils with a low organic carbon content. Evaporation is fairly rapid, followed by reaction with photolytically produced hydroxyl radicals. Direct photolysis is not believed to occur. Rain will result in some removal from the atmosphere. Adsorption to soil particles is moderate. Slow biodegradation in soil is believed possible after adequate acclimation and there is evidence for this same process in ground water. Hydrolysis will not occur in either soil or water (Howard, 1990).

There are no known natural sources of ethylbenzene. Surface waters are generally less that 5 µg/L (Howard, 1990).

o-Xylene

Evaporation and leaching are both significant fate processes for o-xylene released to land. Upon evaporation, the compound will react rapidly with photolytically produced hydroxyl radicals. The half-life of this reaction varies from 1.5 hours in summer to 15 hours in winter. Biodegradation in soil will occur under aerobic and anaerobic/denitrifying conditions. A lag time of up to six months may be required before biodegradation commences under anaerobic conditions. o-Xylene is moderately mobile in ground water. Some adsorption to soil and sediment is likely and o-xylene has remained detectable in soil and ground water for several years at some sites (Howard, 1990).

Natural sources of o-xylene include coal tar, petroleum, forest fires, and volatilization from plants. Surface waters are generally less than 1 µg/L (Howard, 1990).

Naphthalene

Releases of naphthalene to land are moderately adsorbed by soil particles and also undergo biodegradation. Evaporation will be important only for naphthalene in the very near surface layer. Half-lives for biodegradation may be as short as a few hours to days if organisms have been previously acclimated, but as long as a few months if not. In water, volatilization, photolysis, sorption and biodegradation are all important fate mechanisms. In air, photochemically produced hydroxyl radicals rapidly react with naphthalene, as well as nitrates found in polluted urban night air (Howard, 1990).

Natural sources of naphthalene include crude oil and any natural, uncontrolled combustion such as forest fire. Natural surface waters may contain up to 2 µg/L (Howard, 1990).

Pyrene

Pyrene is a polynuclear aromatic hydrocarbon consisting of four aromatic rings. Much of the information on its environmental fate and behaviour can be inferred from data on similar compounds. Releases of pyrene to land will bind strongly to soil particles of adequate organic carbon content and evaporation will not play a significant role in either short or long term fate. Although only sparingly soluble, leaching of pyrene to the ground water may occur over the long term, resulting in considerable persistence in the immediate vicinity of the release. In water, pyrene may be subject to photolysis and, to a lesser extent, oxidation. Biodegradation and biotransformation are also believed to play a role in the long term fate of pyrene (EPA, 1979).

Pyrene is present in the environment due to both natural and anthropogenic sources and has been detected in ambient river water (EPA, 1979).

Metals

None of the metal contaminants present in the bunker fuel sample were at concentrations above relevant guideline levels for soils. In a study for the Ontario Ministry of the Environment (Acres, 1988), metals were measured in road surface materials treated with waste crankcase oil and industrial waste oil, as well as in road ditches near the treated site. Despite the fact that metal concentrations in both waste oils were generally higher than measured in bunker fuel sampled for this study, there was no indication that road materials, road side ditches, and vegetation metals levels were higher than background levels as a result of oil applications. Thus, metals in waste oils were not considered to cause significant environmental impacts. It should be noted that long-term build-up of metals in the environment after several applications is possible due to the persistence of these compounds. However, this impact has not been assessed.

SUMMARY

No field studies on the environmental impacts of bunker fuel as a dust suppressant were identified. The results of the component-based assessment indicate the following:

- Oil is known to be biodegradable, and immiscible, although some solublization of a fraction of oil will occur. The rate of biogredation, volatilization and migration will depend in several site specific factors, which have not been determined.

- Volatile compounds such as chloroform, benzene, ethylbenzene and o-xylene, will not persist at the application site and will be rapidly lost to the atmosphere.

- Lighter PAHs such as naphthalene will be subject to both evaporation and leaching as well as some biodegradation.

- Heavier PAHs such as pyrene may persist for long periods of time at the application site, although some biodegradation and leaching may occur.

- Metals present in bunker fuel oil are not at concentrations that appear to be environmentally significant.

MATERIAL SAFETY DATA SHEET

WHMIS CLASSIFICATION

Combustible Liquid (Class B3)
Poisonous Material (Class D2)

PRODUCT CODE: 410, 420, 430, 440, 441, 442, 443, 445

DATE: February 1, 1990

SECTION I MATERIAL IDENTIFICATION

Trade Name:	HEAVY FUEL OIL
Other Names:	Heavy Fuel Oil 4, 5, 6B; 6C-1.5%, 1.7%, 2.5%, 3.0% S; 806
Chemical Synonyms and Family:	Petroleum hydrocarbon
Name of Manufacturer/Supplier Address & Emergency Phone Number:	Petro-Canada Inc. (403) 296-3000 P.O. Box 2844, Petro-Canada Centre Calgary, Alberta T2P 3E3
Poison Control Centre Numbers:	Consult local telephone directory for emergency numbers.
Application:	Heavy Fuel Oil is used in industrial heating equipment equipped with pre-heaters.

SECTION II TRANSPORTATION

UN Number: 1202 Primary Classification: NR* Subsidiary Classification: NR

Compatibility Groups: NR CANUTEC Transport Emergency No. (613) 996-6666

SECTION III COMPOSITION

COMPONENTS	ALLOWABLE LIMITS (8 hr.)	% (VOL.)	CAS #
Complex mixture of aromatic/aliphatic hydrocarbons (C_9 - C_{50})	nonestablished	≥97	64741-62-4 64741-89-9 68814-87-9 68334-30-5 68955-27-1
Sulphur		≤3	7704-34-9

*All Heavy Fuel Oil 4 and Heavy Fuel Oil 5 from Lake Ontario Refinery, Oakville have a Primary TDG Classification of 3.3.

NR-Not Regulated N/A-Not Applicable U-Unknown

Cette fiche est aussi disponible en français.

Skin: For hot fuel oil splash, cool affected area with water immersion or shower. Remove contaminated clothing - launder before reuse. Soap and water wash. Discard saturated leather articles. Physician assessment if redness or irritation occurs.

Eyes: copious warm water flush - 15 minutes. Physician assessment if eyes inflamed.

Inhalation: Evacuate to fresh air. Apply Cardio Pulmonary Resuscitation if required. Administer oxygen if available. If resuscitation is required, physician assessment is mandatory.

Ingestion: DO NOT INDUCE VOMITING. Force fluids. Activate charcoal tablets. Physician assessment mandatory.

Notes to Physician: The ingestion of heavy fuel oil is an unlikely event. No specific therapy is indicated. Treat with supportive measures as appropriate to the patient's condition.

SECTION VII — REACTIVITY DATA

Stability:	Stable.
Conditions to avoid:	Excessive heat.
Materials to avoid:	Strong oxidizing agents (peroxides, chlorine, strong acids, etc.).
Hazardous Decomposition products:	CO_X, SO_2, NO_X, smoke on combustion.
Can hazardous polymerization occur?:	No.

SECTION VIII — SPILL OR LEAK PROCEDURES

Steps to be taken if material is released or spilled:	Contain spill. Absorb with inert absorbent such as dry clay, sand or diatomaceous earth, commercial sorbents, or recover using pumps. Scoop up used absorbent into drums.
Waste Disposal Method:	Dispose in approved, SECURE landfill site or licenced waste reclaimer facility.

SECTION IV PHYSICAL DATA

Density: (@ 15°C)	0.99-1.0 kg/L	Boiling Point/Range: (@ 1 atm)	N/A
Vapour Pressure: (@ 25°C)	0.7 kPa	Percent Volatile: (@ 20°C)	0%
Vapour Density: (@ 20°C)	Unknown	Evaporation Rate:	N/A
Solubility in Water	Negligible		
Viscosity (Kinematic): (@ 80°C)	9-80 cSt (Fuel Oil 4,5) 80-638 cSt (all others) 6,8		
Pour Point:	-15 to +27°C	Appearance & Odour:	Black viscous liquid with tarry hydrocarbon odour.

SECTION V FIRE & EXPLOSION DATA

Flash Point (method used: COC):	All Heavy Fuel 4 and Heavy Fuel Oil 5 from LOR, Oakville - 84°C min. Others - 62°C min.
Flammable limits in air (% by volume):	N/A
Auto-ignition Temperature:	Unknown
Fire and Explosion Hazards: MODERATE FIRE HAZARD	Addition of water or foam may cause frothing. Do not cut, drill or weld empty containers.
Extinguishing Media:	Foam, dry chemical, water spray, carbon dioxide for small fires.
Fire Fighting Procedures:	Contain spill. Cover with extinguishing agent. Use water spray to cool fire-exposed containers and as a protective screen. Do not point solid water stream directly into burning oil to avoid spreading.

SECTION VI HEALTH HAZARD INFORMATION

Toxicity Data

Acute LC_{50} > 4600 mg/kg (rat, oral): slightly toxic.
Rabbit primary dermal irritation index = 0.7: slightly irritating.
Rabbit eye irritation index = 7.3:
mildly irritating.
Heavy Fuel Oil contains polycyclic aromatic hydrocarbons of which several have been identified as carcinogenic to experimental animals.

Effects of Overexposure:

Inhalation: Due to low volatility, inhalation not likely

Skin and Eyes: Could cause irritation to eyes. Prolonged or repeated contact with skin may cause dermatitis or warty skin growths (keratosis). These growths may become malignant. Hot fuel oil burns skin and eyes.

Ingestion: Ingestion is unlikely.

AVOID SKIN CONTACT.

ventilation:	General ventilation.
Respiratory Protection:	Normally not necessary. If mist generated by excessive heating, wear approved organic vapour respirator suitable for oil mist in areas with sufficient oxygen.
Protective Gloves:	For direct contact with hydrocarbons of more than 2 hours, VITON or NITRILE recommended. Otherwise, PVC gloves may be worn.
Eye Protection:	Chemical goggles if splashing likely.
Other Protective Clothing:	Long sleeved clothing to minimize skin contact.

SECTION X SPECIAL PRECAUTIONS

High standards of personal hygiene are necessary. Wash hands after handling and before eating. Avoid inhalation skin contact. Launder work clothes frequently. Discard saturated leather goods.

SECTION XI REFERENCES

ACGIH. Threshold Limit Values and Biological Exposure Indices for 1987-88.
CONCAWE. First Aid Measures. Medical Toxicology Data and Professional Advice to Clinicians on Petroleum Produ February 1983.
API. Petroleum Process Stream Terms included in the Chemical Substances Inventory Under the Toxic Substances C Act (TSCA), 1983.
API. The Toxicity of Petroleum Hydrocarbons. May 1982.
API. Acute Toxicity Tests. 78-6, 78-7, 78-8, 79-2, 1980.

Petro-Canada and its affiliates assume no responsibility for injury to anyone caused by the material reasonable safety procedures are not adhered to as stipulated in the data sheet. Additionally, Petro- Inc. and its affiliates assume no responsibility for injury to anyone caused by abnormal use of the m even if reasonable safety procedures are followed. Furthermore, vendee and third persons assume th their use of the material.

Petro-Canad

APPENDIX E.10

Rerefined Oil

REVIEW PARAMETER LIST FOR REREFINED OIL

A. GENERAL INFORMATION

Rerefined oils are currently produced at only one location in Ontario: Safety-Kleen Canada Inc. Breslube Division in Breslau, Ontario.

Breslube's base oil is a rerefined paraffinic mineral oil, that contains no additives. It is manufactured from waste oils and has a characteristic petroleum odour. Currently it is not used as a dust suppressant due to a lack of production capacity and company policy. Rerefined oils are used as lubricants in a variety of services.

SUPPLIER/DISTRIBUTOR

Manufacturer

Safety-Kleen Canada Inc.
Breslube Division
Regional Road #17
P.O. Box 130
Breslau, Ontario

Telephone: (519) 648-2291
Fax: (519) 648-2658
Contact: Mr. L.S. Schofield

Applicators/Contractors

Mr. S.L. Schofield at Safety Kleen can provide information on applicators of Breslube as a road dust suppressant.

COST INFORMATION

Rerefined oil from Safety Kleen cost approximately $0.30/L (1991 prices). No application costs are available. If rerefined oils were applied as a dust suppressant, final 1991 costs are estimated at $0.43 to $0.60 per meter season.

SAFETY PROCEDURES

Personal Protection

The following protective measures suggested by the manufacturer will minimize the risk of personal injury in the handling of rerefined oil.

1. Operators should wear chemical goggles if splashing of oil is likely or a high-pressure system is in use.

2. Operators should wear Neoprene or Nitrile gloves under normal use if contact is likely.

3. Operators are not required to wear respiratory protection under normal operations. Operators should wear approved organic vapour respirators suitable for oil mist in areas with sufficient oxygen if mist is generated by heating or spraying.

4. Operators should wear long sleeved clothing to minimize skin contact.

Emergency First Aid

First aid procedures are outlined in the attached Materials Safety Data Sheet for Breslube Base Oils, 1990.

Storage Requirements

Rerefined oil should be stored in cool, well ventilated areas. Contact with strong oxidizing agents such as peroxides, chlorine etc. must be avoided since these will react with oil.

Transportation and Shipping Requirements

No special precautions, other than those normally employed in the transportation of industrial hydrocarbon liquids are necessary.

Spill Procedures

In accordance with Part 9, Section 79 of the Environment Protection Act, a spill is defined as any discharge, intentional or unintentional, of material from its containing unit beyond the recommended maximum application rate into the natural environment.

This can be caused by spray bars left on after operation, tank rupture, tank turn over, etc. In the event of a spill the following procedures are recommended:

1. The spill should be contained using sand or earth to prevent rerefined oil from entering water ways or low areas. All sources of ignition must be removed.

2. As much as possible of the spilled oil should be recovered with pumping equipment or absorbent material.

3. The remaining spilled oil should be absorbed with sand, or diatomaceous earth or commercial solvents.

4. The following should be contacted:

   - All local municipal authorities
   - The Spill Action Centre, at 1-800-268-6060.
   - Environment Canada at The Ontario Regional Environmental Emergencies line: (416)-973-1059, or (416)-346-1971 (cellular).
   - Breslube should be contacted at (519) 648-2291.

SOURCE DESCRIPTION AND QUALITY CONTROL

Breslube obtains its feed stock of used oil from various automotive retailers, industries, and highway transportation agencies. The types of oils vary and can include used hydraulic fluids, quench oils, gear oils, machine oils, and crankcase oils.

All used oils are stored in a large holding tank prior to treatment. The treatment process is comprised of four main steps. The oil is first dehydrated with steam and a moderate vacuum in a dehydrator. This step removes water, gasoline, and other low boiling point hydrocarbons. The next step is vacuum stripping at 666 Pa and 288 °C, to remove kerosine from the oil. The oil is then treated in a thin film distillation unit at the same low pressure, at 377 °C to remove asphalt. The remaining oil is then sent to the last processing step: hydrotreating at 5,517 kPa. The oils produced from this step are high quality base oils that are sold back to the major oil companies for additive treatments, or sold to other customers for various uses.

Quality Control

Safety Kleen has an extensive QA/QC program identical in nature to those used by the major oil refineries. Feed stock waste oil is tested for various parameters including PCB's, metals, halogens, sulphur and chlorine, as well as physical parameters. PCB

limits are set at 2 mg/L for feedstock waste oil. Oils with higher concentrations must have written permission to be accepted on site for processing. Note that any PCB in the waste oil are reported to be destroyed in the hydrotreating process which produces caustic and saleable oil. All process parameters throughout the plant are monitored and recorded. The finished rerefined oil is tested for several parameters including viscosity, colour, acid, flash point, pour point etc. Finished rerefined oil properties can be accurately controlled by the process conditions in the four main units.

B. TECHNICAL EFFECTIVENESS AND APPLICATION PROCEDURE

TECHNICAL EFFECTIVENESS

No specific literature on the technical effectiveness of rerefined oil exists. However, it is believed that all oil products are generally as effective in controlling dust and stabilizing roads as waste oil products previously used. Thus, literature on the technical effectiveness of used oil as a dust suppressant and road stabilizer is also applicable to rerefined oil performance. Oil controls dust primarily by soaking into the surface, wetting and agglomerating the aggregate particles and preventing them from becoming airborne by the natural cohesive nature of the oil. To evaluate the technical effectiveness of rerefined oils, a literature survey and a telephone survey of current and past users of virgin and used oil in Ontario was conducted. (1991).

The results of the telephone survey conducted for this study indicated rainfall did not reduce the dust suppressing abilities of virgin or used oils used on roads as noticeably as with other dust suppressants such as calcium chloride, lignosulphonates, etc. Users suggested that oil resists leaching and runoff more than other types of suppressants. However, very rainy conditions do have a tendency to make oil treated surfaces slippery, and may also promote potholing of municipal roads.

A Canada wide survey conducted by the British Columbia Ministry of the Environment (British Columbia, 1981) solicited mailed responses from various road agencies across Canada to find alternative dust suppressants to used oil. The results showed that oil was preferred in wet climates because longer periods of effective dust suppression resulted for oil treated roads compared to roads treated with other suppressants.

Traffic density and vehicle weights are variables in the effectiveness of oil in controlling dust emissions from roads and yards. The results of a survey of 15 Canadian and 2 U.S. highway agencies (Public Works Canada, 1983) showed that oil is the most popular road stabilizer and dust suppressant in areas with heavy truck traffic or high volume traffic. The telephone survey confirmed that industrial sites using heavy trucks, front end loaders, forklifts etc. also use virgin oil to suppress dust. No other dust suppressant is reported as effective for the same length of time as oil products. However, the effectiveness of the oil is reduced when sharp turns and stops from trucks wear the surface. This action also promotes potholing.

The overall effectiveness of oil products over other chemicals was shown in a study carried out for the Ontario Ministry of the Environment (Acres, 1988). This study compared the technical effectiveness of used oil and industrial oil against other dust suppressants used on municipal roads in Southern Ontario. No surface aggregate compositions or application rates were reported. Dust emitted from the treated road surface over a three month period was measured at various sites, where a number of dust suppressants had been applied. Results indicated that the oil applications provided the best dust control over all other dust suppressants tested. Dust measurements taken from a moving vehicle travelling over the treated surface also indicated that dust emissions from the oil treated surfaces were the lowest of all suppressants tested.

In general, Ontario users have found that oil is the only suppressant that provides an acceptable level of dust suppression in sandy soils or open gravel (i.e. gravel with very little fines), or in areas with little or no moisture in the surface. However, a report on road surface treatments in Alaska (State of Alaska, 1982) indicated that the presence of large amounts of fines, particularly clays, can promote the absorption of petroleum based palliatives into the surface particles, which would reduce the binding effects of the dust palliative and the natural cohesive nature of the fines. This would result in soft spots in the surface and eventual potholing.

Summary of Overall Effectiveness

The performance of virgin oils is determined by several factors including:

1. Oil products resist leaching and runoff resulting from precipitation to a greater extent than other dust suppressants.

2. Oil has been shown to have a longer effective dust suppression period in wet weather then other dust suppressants.

3. Oil is a superior dust suppressant in areas that have heavy weight or high volume traffic because of its effectiveness and lifetime compared to the performance of other dust suppressants.

4. Oil has been shown to provide the highest level of dust control over other dust suppressants in several areas.

5. Oil is better suited as a road treatment for sandy surfaces, and dry open gravel surfaces where other dust suppressants may not be as effective.

6. Oil may promote potholing in road surfaces with high clay content.

APPLICATION PROCEDURES

Site Restrictions

According to the Ontario Ministry of Environment's Draft Guidelines for the Application of Dust Suppressants, dust suppressants should not be applied to sites closely adjacent to, or crossing, waterway(s), marshes, or wells.

Surface Preparation

Published literature prescribing the road preparation procedures for the application of rerefined oil were not identified in the information search. Road preparation information was obtained from the telephone survey conducted for this study with municipalities and the contractors that use and apply virgin oil.

According to the telephone survey, surface preparation usually consists of no more than grading to remove potholes and corrugations. However, a general preparation for the road surface to insure proper application is as follows:

1. Proper drainage should be provided on both sides of the road.

2. The surface should be graded to a significant depth (20 to 50 mm) to remove pot holes, corrugations and other ruts. If the road is deeply rutted or corrugated it may require scarification between 25 and 100 mm.

3. Gravel or fines should be added as required to yield a final composition of up to 8 percent fines (<200 mesh).

4. Rerefined oil should be applied desired levels while the surface still retains some moisture (this aids in wetting of the particle surfaces and helps prevent dust pockets from forming).

5. Compaction of the surface is suggested to provide a firm solid base, particularly if the surface is being newly constructed.

Application Equipment

Application equipment for oils is usually a bituminous distributor. The Ontario Ministry of Transportation requires that the distributor be equipped with a pump capable of developing a constant uniform pressure in the spray bar manifold. In addition, the spray bar must be capable of application over a variety of widths. The distributor tank should also come equipped with a dip stick for measuring quantities applied.

A general equipment list for bituminous distributors also contains the following:

- Recirculation in the tank.
- A quick opening gate in the dome.
- An external readily visible tank gauge.
- Rear mounted spray bars and nozzles 0.6 to 3.6 m wide capable of:
  - vertical and lateral adjustment
  - producing double coverage in one pass.
- Spray bars that do not extend into the lane of opposing traffic unless adequate warning measures are taken.
- The feed to the spray bars equipped with:
  - recirculation before and during operation and
  - filters.
- Spray nozzles:
  - fitted with instant on/off valves, and,
  - which yield fan-shaped sprays without atomization.
- A pressure pump capable of supplying approximately 726 L/min of oil.
- An operator visible 345 MPa pressure gauge.
- An operator visible flow meter.
- An operator visible pump tachometer.

Personnel Requirements

Typically two to four people are required for safe applications. This would consists of at least one, maybe two, flag-persons and/or an operator of a warning pilot vehicle, the operator of the application truck, and an application checker (the flag person can double as a checker).

Length of Time Before and After Precipitation

Application of rerefined oil should be made no sooner than 6 to 12 hours after a significant rainfall, but while the soil still retains some moisture. This will prevent dust beads from forming, and there by preventing wetting of the soil aggregate by the oil.

In addition, application should not be made within 6 hours of expected rainfall to permit complete saturation, penetration, and absorption of the oil into the road surface and to avoid leaching and runoff.

Dilution

Rerefined is not normally diluted for application. Rerefined oils should not be mixed with anything than other virgin hydrocarbon base oils for the purpose of thinning. Strong oxidizing agents should be particularly avoided since these will react with oils.

Application Frequency and Rate

Rerefined oils are not currently used for dust suppression. Therefore, information is not available on application rates for rerefined oils. Information is provided for virgin oil application, since these oils are believed to behave the same for dust suppression and road stabilization.

Virgin oils are usually applied once per season in Ontario at municipal road and industrial sites. Some very heavy industrial locations may apply twice per season. According to a survey of various highway agencies in Canada and the U.S. (Public Works Canada, 1983), application of oil products ranged from two light applications per year of about 0.8 to 1.7 L/m^2 to one heavy application in Alberta of about 2.5 to 3.0 L/m^2 every two to three years. Ontario industrial application rates vary from 0.3 L/m^2 to 1.9 L/m^2, and municipal application rates are from 1.1 to 1.3 L/m^2. Subsequent applications, if made, are at the same rates as initial applications.

Ponding should be avoided during application. Ponding will depend on several factors: the rate of oil discharge, the speed of the application truck, and the porosity of the surface materials. Ponding can be prevented by shutting off the spray bars when the vehicle/truck is stopped or is passing over paved/sealed portions of the road. Care should also be exercised to ensure that the oil is applied at or below the suggested rates. If ponding still occurs, then a decrease in the application rate is necessary.

Curing Time

There is no curing time associated with rerefined oil. It remains in the viscous liquid state. Traffic can be permitted immediately following application, but 1/2 hour of slowed traffic is recommended to permit adequate penetration.

Problems and Hazards

Driving over freshly applied oil may cause splashing onto cars. Heavy rains on roads with high clay content treated with oil may cause slippery conditions since the oil acts as a lubricant between clay particles.

C. PHYSICAL AND CHEMICAL CHARACTERISTICS

PHYSICAL PROPERTIES

Three grades of rerefined oil from Safety Kleen, Breslube Division in Breslau, Ontario were provided for the study. The physical characteristics of each of the three grades are presented below in Table 1.

Table 1
Physical Properties of Rerefined Oil

Property	Breslube 85H	Breslube 100H	Breslube 150H
Odour	Hydrocarbon	Hydrocarbon	Hydrocarbon
Appearance and colour before application	Amber liquid	Amber liquid	Amber liquid
Physical state when Applied	Viscous liquid	Viscous liquid	Viscous liquid
Physical state when dried	Viscous liquid	Viscous liquid	Viscous liquid
pH	NA	NA	NA
Solubility in water	Negligible	Negligible	Negligible
Vapour pressure relative to water	Less than	Less than	Less than
Thermodynamic reaction with water	Neutral	Neutral	Neutral
Flammability/flash point	190 °C	200 °C	171 °C
Boiling point	260 °C	260 °C	260 °C
Specific gravity @ 15.5 °C	0.85 - 0.88	0.85 - 0.88	0.85 - 0.88
Viscosity	3.44 cSt at 100 °C	3.97 cSt at 100 °C	3.97 cSt at 100 °C

Source: Breslube Base Oils Materials Safety Data Sheet from Safety Kleen
NA: Not Analyzed

CHEMICAL PROPERTIES

Breslube base oils are 100 percent rerefined lubricating oils that do not contain additives.

Three grades of rerefined oil were provided by Breslube for this study. For the purposes of chemical analyses, all three samples were composited in the laboratory, and split for duplicate analyses of conventional parameters, metals, volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons and PCBs. All analyses were carried out by CANVIRO Analytical Laboratories Ltd. The averaged results for the duplicate samples are presented in Table 2.

Table 2
Chemical Characteristics of Rerefined Oil[1]

	Units	Concentration[1]
Conventional Parameters		
pH	mg/L	9.7
Total solids	mg/L	732,000
Ammonium Nitrogen	mg/L	<500
Total Phosphorus	mg/L	17
Metals		
Aluminum	mg/L	4
Boron	mg/L	7.5
Barium	mg/L	<2
Beryllium	mg/L	<0.5
Cadmium	mg/L	<0.2
Calcium	mg/L	5
Chromium	mg/L	<0.5
Cobalt	mg/L	<0.5
Copper	mg/L	<0.5
Iron	mg/L	<0.5
Lead	mg/L	<1
Magnesium	mg/L	2
Manganese	mg/L	<0.5
Vanadium	mg/L	<0.5
Zinc	mg/L	<1
Nickel	mg/L	<0.5
Silver	mg/L	<0.5
Strontium	mg/L	<0.5
Sodium	mg/L	10
Arsenic	mg/L	<0.2
Selenium	mg/L	<0.1
Mercury	mg/L	<0.02
Polynuclear Aromatic Hydrocarbons		
Naphthalene	µg/L	17,800
Acenaphthylene	µg/L	<80
Acenaphthene	µg/L	8,650
Fluorene	µg/L	19,200
Phenanthrene	µg/L	124,500
Anthracene	µg/L	<160
Fluoranthene	µg/L	20,150
Pyrene	µg/L	63,450
Benzo (a) anthracene	µg/L	12,900
Chrysene	µg/L	23,850
Benzo (b) fluoranthene	µg/L	<140
Benzo (k) fluoranthene	µg/L	<140
Benzo (a) pyrene	µg/L	9,275
Indeno (1,2,3-cd) pyrene	µg/L	3,295
Dibenzo (a,h) anthracene	µg/L	<160
Benzo (ghi) perylene	µg/L	5,755

Table 2
Chemical Characteristics of Rerefined Oil[1]

	Units	Concentration[1]
Volatile Organic Compounds		
Methyl ethyl ketone	µg/L	2,485
Chloroform	µg/L	985
Carbon tetrachloride	µg/L	<70
Benzene	µg/L	<40
Toluene	µg/L	3,285
m&p Xylene	µg/L	690
Ethylbenzene	µg/L	437.5
o-Xylene	µg/L	1,550
Chloromethane	µg/L	<360
Vinyl Chloride	µg/L	<500
Bromomethane	µg/L	<200
Chloroethane	µg/L	<160
Trichlorofluoromethane	µg/L	<350
Acrolein	µg/L	<220
1,1-Dichloroethylene	µg/L	<160
Methylene Chloride	µg/L	<180
Acrylonitrile	µg/L	<210
Trans-1,2-Dichloroethylene	µg/L	<70
1,1-Dichloroethane	µg/L	<50
Bromochloromethane	µg/L	<20
1,1,1-Trichloroethane	µg/L	<50
Carbon Tetrachloride	µg/L	<70
1,2-Dichloroethane	µg/L	<30
Trichloroethylene	µg/L	<190
1,2-Dichloropropene	µg/L	<20
2-Chloroethylvinyl ether	µg/L	<40
Trans-1,3-Dichloropropylene	µg/L	<30
Cis-1,3-Dichloropropylene	µg/L	<50
1,1,2-Trichloroethane	µg/L	<30
Tetrachloroethylene	µg/L	<80
Dibromochloromethane	µg/L	<20
Ethylene dibromide	µg/L	<60
Chlorobenzene	µg/L	<20
Styrene	µg/L	<40
Bromoform	µg/L	<30
1,1,2,2-Tetrachloroethane	µg/L	<50
1,3-Dichlorobenzene	µg/L	<20
1,4-Dichloroebenzene	µg/L	<10
1,2-Dichlorobenzene	µg/L	<40
Polychlorinated Biphenyls		
PCB-1242	µg/L	<120
PCB-1254	µg/L	<256
PCB-1260	µg/L	<256
Total PCB	µg/L	not detected

Notes:

1. Average of duplicate analyses carried out on composite of rerefined oil. Grades were Breslube 80H, 100H and 150H from Safety-Kleen, Breslube Division.

< Below detection limit.

NA Not detected.

Rerefined oil contains low concentrations of a few metals, including aluminum and boron. Several light, middle and heavier PAH compounds were identified at concentrations up to 124,500 µg/L. VOCs present in rerefined oil include methylene chloride, chloroform, toluene, ethylbenzene and m,o&p-xylenes at concentrations up to 3,285 µg/L. No PCBs were detected in the sample.

D. ACUTE TOXICITY AND SUB-LETHAL EFFECTS

ACUTE TOXICITY

B.A.R. Environmental conducted duplicate acute toxicity tests on the same samples of Breslube rerefined oil used for chemical analyses. The test measured the lethal effects of 10,000 mg/L solutions on the test species, rainbow trout and Daphnia magna aged for 24 and 96 hours. This is a slight deviation from normal LC50 procedures, since the rerefined oil will not dissolve in water. Therefore, the toxicity data represents the toxicity of the compounds that dissolved into the water from the oil after a prescribed amount of time. Test results are presented in Table 3.

Table 3
Acute Toxicity of Breslube Rerefined Oil

Organism	Test Solution Aging Period Prior to Use (h)	Length of Time Organism Was exposed to Acid Test Solution (h)	Effect on Organism	Concentration (mg/L)	95 Percent Confidence Interval (mg/L)
Rainbow Trout	24	96	Non-Lethal	10,000	NA
	96	96	30% Mortality	10,000	NA
Daphnia Magna	24	48	25% Mortality	10,000	NA
	96	48	Non-Lethal	10,000	NA

Notes:

NA: Not Applicable

The toxicity data indicates that 10,000 mg/L of rerefined Breslube oil is lethal to 30 percent of the rainbow trout after an aging period of 96 hours, and lethal to 25 percent of the Daphnia Magna after 24 hours aging. A lethal concentration (LC50) of the rerefined oil was not identified.

Other Toxicity Information

Rerefined oil from Breslube is non-lethal to rats with an LD50 >5 g/kg, both oral and dermal (Breslube Base Oils, MSDS, 1989).

SUBLETHAL EFFECTS

To assess the sub-lethal effects of Breslube rerefined oil, the effects of individual chemical components present at concentrations above the guidelines and standards for drinking water and/or aquatic life, presented in Table 4, were reviewed.

Table 4
Comparison of Contaminant Limits for Drinking Water and Aquatic Life to Concentrations in Rerefined Oil (from Breslube)[1]

Parameter	Aquatic Life	Drinking Water	Rerefined Oil
Aluminum (µg/L)	5-100[2,4]	200[5]	4,000
Boron (µg/L)	N/A	5,000[2,3]	7,500
Methyl ethyl ketone (µg/L)	N/A	N/A	2,485
Chloroform (µg/L)	2[4]	5[6], 70[8], 350[2]	985
Ethybenzene (µg/L)	700[4]	2.4[3]	437.5
Toluene (µg/L)	300[4]	24[3]	3,285
m&p-Xylene (µg/L)	N/A	30 (m-xylene)[3], 30 (p-xylene)[3]	690
o-Xylene (µg/L)	N/A	30[3]	1,550
Naphthalene	N/A	N/A	17,800
Acenaphthene	N/A	N/A	8,650
Fluorene	N/A	N/A	19,200
Phenanthrene	N/A	N/A	124,500
Fluoranthene	N/A	N/A	20,150
Pyrene	N/A	N/A	63,450
Benzo (a) anthracene	N/A	N/A	12,900
Chrysene	N/A	N/A	23,850
Benzo (a) pyrene	N/A	0.2 (total for 6 PAH)	9,275
Indeno (1,2,3-cd pyrene)	N/A	0.2 (total for 6 PAH)	3,295
Benzo (ghi) perylene	N/A	0.2 (total for 6 PAH)	5,755

Notes:

1. Only parameters with concentrations exceeding referenced limits are presented.
2. Ontario Ministry of the Environment, 1984. Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.
3. Health and Welfare Canada, 1987. Canadian Guidelines for Drinking Water.
4. Environment Canada and Health and Welfare Canada, 1991. How Safe is Our Water?
5. World Health Organization, 1984. Guidelines for Drinking Water Quality, Volume 2 Health Criteria and other supporting information.
6. E.P.A. Cited from W.H.O. literature.
7. Cited from MOE literature.

Comparing the concentrations of toxic substances in 100 percent strength of the dust suppressant product provides an indication of toxicity to human and aquatic life only on a "worst case" basis. Some dilution effects will occur once the material is released to land and exposed to the effects of runoff, leaching and degradation. In addition, concentration of persistent substances after repeated application may also occur. The exact extent of dilution or build-up will depend largely on site specific factors and will not be addressed in generic assessments of sub-lethal effects.

In the absence of a detailed exposure and risk assessment, it is not possible to completely assess the degree of human or environmental health risk posed by rerefined oil. The following discussion attempts only to identify the contaminants of concern which could potentially cause problems over the long term. In many cases, the toxological data available is limited.

Main Components

Like other hydrocarbon compounds, the acute oral toxicity of rerefined oil is very low. However, the fumes or mists of the oil are irritating to the eyes, mucous membranes and upper respiratory tract, and can cause headache, dizziness and/or drowsiness if exposure is excessive (Breslube Oil MSDS, 1988).

Prolonged contact of rerefined oil may result in defatting, oil acne, redness, itching, inflammation, cracking and possible secondary infection. It may also cause allergic reaction in some individuals. Slight dermal absorption could occur, but not to any significant degree (Breslube Oil MSDS, 1989).

Contaminant Based Assessment

PAH compounds found in Breslube rerefined oil have been shown to have teratogenic, mutagenic and/or carcinogenic properties in animals and are probable human carcinogens. They may also bioaccumulate in aquatic life. However, the heavier PAH compounds, which are those of most concern, such as benzo (a) pyrene, are likely to remain closely associated with roadbed materials and are not very mobile. Therefore, contamination of drinking water, groundwater or surface water is unlikely. Ingestion and inhalation of road dust, or mist during application, may be more likely routes of exposure. There are many natural and anthopogenic sources of PAH.

Volatile organic compounds found in Breslube rerefined oil, are known to be potentially toxic. Ethylbenzene, toluene and xylenes, for example, may cause adverse effects. However, given that most of these compounds will be rapidly lost to the atmosphere via evaporation after application, it is perhaps more likely that VOCs would be of concern to applicators as opposed to by standards or property owners. In the case of industrial site applications, on site worker exposure may be of concern.

Two metals, aluminum and boron, were present at levels slightly above relevant drinking water quality guidelines. Guidelines are based on lifetime consumption of 1.5 L of water per day, and incorporate significant safety factors. Thus, these compounds appear to be insignificant with respect to human health concerns.

SUMMARY

The following points summarize the acute toxicity and sub-lethal effects of rerefined oil:

- At concentrations of 10,000 mg/L of oil in 1 L of water, aged for 96 h, re-refined oils were non-lethal to rainbow trout or Daphnia magna. An oral and dermal LD50 of >5 g/kg has been reported for rats.

- Rerefined oil may cause dermal and eye irritation on contact or if exposed to mist, and other effects if fumes are inhaled.

- PAH contaminants in rerefined oil would not likely contaminant water supplies. However, exposure may occur through inhalation of oil mist during application or road dust.

- VOC contaminants in rerefined oil may pose human health concerns to applicators or industrial workers at application sties. Long term concerns would not exist, because compounds evaporate rapidly from application site.

E. ENVIRONMENTAL IMPACTS

MAIN DUST SUPPRESSANT COMPONENTS

No literature sources describing field studies of the environmental impacts of rerefined oil as a dust suppressant were identified.

Rerefined oil is one hundred percent lubricating oil. Although its movement through the environment has not been evaluated, it can be described in general terms. The oil is for the most part, immiscible and has a higher viscosity than water, and therefore, migration will not be affected by water movement. Oil will migrate from the application site by leaching and penetrating into soil, and will be slowed by soil adsorption. Some components of the oil will solubilize in passing waters and leach away. Lighter fractions of the oil will volatilize, although the portion and rate of volatilization has not been determined. The entire product is biodegradable, and lighter fractions will biodegrade in the environment more quickly. The overall rate of decay in the environment has not been determined. In soil, the Ontario MOE's guidelines for site clean-up recommend that oil and grease levels should not exceed 1 percent by weight.

Analysis of BOD or phosphorus were not possible because the product is largely immiscible. Apart from acute toxicity effects, rerefined oil floats on water and will create negative aesthetic impacts, including slicks and sheens.

CONTAMINANT BASED-ASSESSMENT

Since rerefined oil is not marketed as a dust suppressant, no field studies have been conducted regarding its environmental impacts in this application. Examination of the individual components of the product provide the "next best" assessment of environmental fate. The analytical results of this study have been used to develop a short list of components which represent a range of possible fates for rerefined oil which is released to land.

Table 5 presents those contaminants in rerefined oil that exceed guideline levels for soils.

Table 5
Comparison of Contaminant Limits in Soil to Levels in Breslube Rerefined Oil[1]

Parameter	Soil Concentrations	Rerefined Oil
Naphthalene	100 µg/kg[2]	17,800 µg/L
Acenaphthene	N/A	8,650 µg/L
Fluorene	N/A	19,200 µg/L
Phenanthrene	100 µg/kg	124,500 µg/L
Fluoranthene	N/A	20,150 µg/L
Pyrene	100 µg/kg[2]	63,450 µg/L
Benzo (a) anthracene	100 µg/kg[2]	12,900 µg/L
Chrysene	N/A	23,850 µg/L
Benzo (a) pyrene	100 µg/kg[2]	9,275 µg/L
Indeno (1,2,3-cd) pyrene	100 µg/kg[2]	3,295 µg/L
Benzo (ghi) perylene	N/A	5,755 µg/L
Chloroform	100 µg/kg[2]	985 µg/L
Methyl ethyl ketone	N/A	2,485 µg/L
Toluene	100 µg/kg[2]	3,285 µg/L
Total xylenes	100 µg/kg[2]	690 µg/L (m & p-xylene), 1,550 µg/L (o-xylene)
Ethylbenzene	100 µg/kg[2]	437.5 µg/L

Notes:

1. Only parameters with concentrations exceeding referenced levels are presented.
2. Canadian Council of Ministries of the Environment, 1991. Interim CCME Environment Quality Criteria for Contaminated Sites, Final Draft. These values are interim assessment criteria and are to be considered background or recommended detection limit values.

Organic Compounds

In order to assess a range of persistence and migration characteristics of the organic compounds of rerefined oil, representative compounds from each group were selected for further discussion.

For assessment of environmental impacts of the PAH compounds exceeding guideline levels presented in Table 5, three compounds were selected for further discussion to represent the range of possible environmental fates for this group of compounds. Naphthalene is the lightest molecule in the group, pyrene, a middle weight molecule, and benzo (a) pyrene, a heavier end compound.

Several volatile organic compounds were present in rerefined oil at concentrations exceeding guideline levels for soils, presented in Table 5. Chloroform, ethylbenzene and o-xylene were selected as representative volatile organic compounds.

For organic contaminants, environmental fate and behaviour can be at least partially predicted through a knowledge of physical/chemical properties such as those presented in Table 6 for the selected organic components.

Table 6
Physical/Chemical Properties of Selected Components of Rerefined Oil[1]

Component	Component Group	Molecular Weight (g/g-mole)	Vapour Pressure (mm Hg at 25 °C)	Aqueous Solubility (mg/L at 25 °C)	log Octanol-Water Partition Coefficient	Henry's Law Constant (atm-m^3/ g-mole at 25°C)
Chloroform	VOC	119.39	246	7950	1.97	4.35×10^{-3}
Ethylbenzene	VOC	106.16	9.53	161	3.15	8.44×10^{-3}
o-Xylene	VOC	106.16	6.6	175	3.12	5.1×10^{-3}
Naphthalene	PAH	128.16	0.082	31.7	3.30	4.83×10^{-4}
Pyrene[2]	PAH	202	6.85×10^{-7} at 20°C	0.14	5.32	-
Benzo(a)pyrene[2]	PAH	252	5×10^{-9}	0.0038	6.04	-

Notes:

1. Data taken from Howard (1989 and 1990) except as noted.
2. Data taken from U.S. EPA (1979). Values for Henry's Law Constant were not available.

It is difficult to assess the combined effects of all the properties noted in Table 6 based solely on a review of the data. The Fugacity Level I model has been used to achieve a measure of the combined effects of these properties. Results for the chemicals of interest are reported in Table 7. It should be emphasized that this model does not consider which environmental compartments receive releases of the chemical, nor the rate at which equilibrium is achieved. Also not taken into consideration are degradation reactions which may deplete the amount of chemical in the model environment.

Table 7 Results of Level I Fugacity Modelling				
Component	Percentage of Component in Each Environmental Compartment at Equilibrium			
	Bulk Air	Bulk Water	Bulk Soil	Bulk Sediment
Chloroform	95.19	4.79	0.02	0.00
Ethylbenzene	96.99	2.88	0.12	0.01
o-Xylene	95.37	4.44	0.18	0.01
Naphthalene	62.71	35.02	2.10	0.17
Pyrene	0.16	15.38	78.20	6.26
Benzo(a)pyrene	0.86	5.69	86.53	6.92

Since the Fugacity Level I model bases predictions of environmental fate solely on physical/chemical properties, the following paragraphs on each of the components of interest have been provided to summarize literature information on the relative importance of various fate mechanisms including:

- Evaporation
- Adsorption
- Degradation through biodegradation, photolysis, hydrolysis, etc.
- Migration in water

These paragraphs also attempt to describe the fate of releases to land since this is the scenario involved in the use of dust suppressants, as well as the movement of the chemical through the environment as equilibrium is approached.

Where available, information on concentrations of each of the components in various environmental media is also provided.

Chloroform

The fate of releases of chloroform to land and water will be primarily evaporation to the atmosphere owing to chloroform's extremely high vapour pressure. Chloroform in the atmosphere will be transported long distances and will react with hydroxyl radicals formed by photochemical reactions. The half-life for this reaction is a few months. Some chloroform from land releases will leach into ground water where it may reside for considerable periods of time. However, rapid evaporation from near-surface soils should occur. Biodegradation may be a significant process, but data on this subject are somewhat conflicting. Adsorption to soil particles will not be significant, nor will it hydrolyse in water or soil under normal environmental conditions (Howard, 1990).

The only known natural source of chloroform is volatilization from plants. Chlorination of drinking water supplies leads to the formation of chloroform and other trihalomethanes and levels averaging 35 µg/L in summer in Canada have been detected. Surface water levels are generally less than 50 µg/L (Howard, 1990).

Ethylbenzene

When released to land, some evaporation of ethylbenzene will occur, along with adsorption to soil particles and leaching to ground water. The latter process will be more significant in soils with a low organic carbon content. Evaporation is fairly rapid, followed by reaction with photolytically produced hydroxyl radicals. Direct photolysis is not believed to occur. Rain will result in some removal from the atmosphere. Adsorption to soil particles is moderate. Slow biodegradation in soil is believed possible after adequate acclimation and there is evidence for this same process in ground water. Hydrolysis will not occur in either soil or water (Howard, 1989).

There are no known natural sources of ethylbenzene. Surface waters are generally less that 5 µg/L (Howard, 1989).

o-Xylene

Evaporation and leaching are both significant fate processes for o-xylene released to land. Upon evaporation, the compound will react rapidly with photolytically produced hydroxyl radicals. The half-life of this reaction varies from 1.5 hours in summer to 15 hours in winter. Biodegradation in soil will occur under aerobic and anaerobic/denitrifying conditions. A lag time of up to six months may be required before biodegradation commences under anaerobic conditions. o-Xylene is moderately mobile in ground water. Some adsorption to soil and sediment is likely and o-xylene has remained detectable in soil and ground water for several years at some sites (Howard, 1990).

Natural sources of o-xylene include coal tar, petroleum, forest fires, and volatilization from plants. Surface waters are generally less than 1 µg/L.

Naphthalene

Releases of naphthalene to land are moderately adsorbed by soil particles and also undergo biodegradation. Evaporation will be important only for naphthalene in the very near surface layer. Half-lives for biodegradation may be as short as a few hours to days if organisms have been previously acclimated, but as long as a few months if not.

In water, volatilization, photolysis, sorption and biodegradation are all important fate mechanisms. In air, photochemically produced hydroxyl radicals rapidly react with naphthalene, as well as nitrates found in polluted urban night air (Howard, 1989).

Natural sources of naphthalene include crude oil and any natural, uncontrolled combustion such as forest fire. Natural surface water may contain up to 2 µg/L (Howard, 1989).

Pyrene

Pyrene is a polynuclear aromatic hydrocarbon consisting of four aromatic rings. Much of the information on its environmental fate and behaviour can be inferred from data on similar compounds. Releases of pyrene to land will bind strongly to soil particles of adequate organic carbon content and evaporation will not play a significant role in either short or long term fate. Although only sparingly soluble, leaching of pyrene to the ground water may occur over the long term, resulting in considerable persistence in the immediate vicinity of the release. In water, pyrene may be subject to photolysis and, to a lesser extent, oxidation. Biodegradation and biotransformation are also believed to play a role in the long term fate of pyrene (EPA, 1979).

Pyrene is present in the environment due to both natural and anthropogenic sources and has been detected in ambient river water (EPA, 1979).

Benzo(a)pyrene

Benzo(a)pyrene (BaP) is a polynuclear aromatic hydrocarbon consisting of five aromatic rings. It has extremely low solubility and vapour pressure and a strong affinity for the organic phase, as indicated by a high octanol water partition coefficient. Therefore, releases of BaP on land will be subject to relatively little evaporation or runoff in a dissolved form. The compound will adsorb strongly to soil particles, especially in organically rich soils. Long term leaching of soil bound BaP may occur. In surface water, direct photolysis will probably occur at a rapid rate, while slow biodegradation and biotransformation will also contribute to ultimate fate (EPA, 1979).

Metals

None of the metal contaminants present in the rerefined oil sample were at concentrations above the guidelines for soils. In a study for the Ontario Ministry of the Environment (Acres, 1988), metals were measured in road surface materials treated with waste crankcase oil and industrial waste oil, as well as in road ditches and vegetation near the treated site. Despite the fact that metal concentrations in both waste oils were generally higher than measured in the rerefined oil sampled for this study, there was no indication that road oils, road site ditches and vegetation metals levels were

higher than background levels as a result of oil applications. Thus, metals in waste oils were not considered to cause significant environmental impacts. However, long term build-up of metals after frequent applications has not been examined.

SUMMARY

The following main points summarize the environmental impacts of rerefined oil application for dust suppressions.

- Field studies have not been identified which examined the migration or persistence of rerefined oil on the environment.
- Oil is known to be biodegradable, and immiscible, although some solubization of a fraction of oil will occur. The rate of biogredation, volatilization and migration will depend in several site specific factors, which have not been determined.
- Volatile components will have no significant long term impacts at the application site since they will be lost to evaporation.
- Lighter PAHs such as naphthalene will be subject to both leaching and evaporation.
- Heavier PAHs such as pyrene and benzo(a)pyrene will persist at the application site for long periods of time, although some leaching and biodegradation will occur.
- Metals present in rerefined oils are not at concentrations considered to be environmentally significant.

MATERIAL SAFETY DATA SHEET
BASE OILS

SECTION I -- IDENTITY INFORMATION

BRESLUBE
DIVISION OF SAFETY KLEEN CANADA INC.
REGIONAL ROAD #17
P. O. BOX 130
BRESLAU, ONTARIO, CANADA
EMERGENCY PHONE NUMBERS:
519-648-2291
519-648-2204 (24 HOURS)
1-800-265-2444 (ONTARIO)
1-800-265-2792 (U.S.A.)
PRODUCT IDENTIFIER: BresLube - - 85HT - B500HT Base Oils
Family/Chemical Name: Re-refined lubricating oil; Hydrocarbon
SYNONYMS: HVI paraffinic petroleum oil
PRODUCT USAGE: A base oil which does not contain additives. Used for certain lubrication activities and as a base oil which may be blended with additives.
This Material Safety Data Sheet is prepared as a generic sheet for the family of products listed in the Identity section above.

SECTION II -- HAZARDOUS INGREDIENTS

These products are not hazardous in their normal intended usage. However if these products are to be used in applications where oil mists are generated, please refer to the section of this sheet entitled Other Information.

SECTION III -- PHYSICAL DATA

PHYSICAL STATE: Liquid
APPEARANCE AND ODOUR: Amber viscous liquid with a characteristic petroleum odour.
Odour threshold: Not determined
BOILING POINT: Wide range. Generally > 260°C (500°F)
FREEZING POINT: Not applicable

EVAPORATION RATE: Very slow at room temperature. Approx. 1000X slower than ethyl ether.
PERCENT VOLATILE: Negligible
VAPOUR DENSITY: Not determined. Heavier than air.
VAPOUR PRESSURE: At 25°C, <1 x 10^{-3} mm Hg estimate from similar product
SOLUBILITY IN WATER: At 20°C, insoluble
PH: Not determined.
SPECIFIC GRAVITY: Approx. 0.85 - 0.88 @ 15.5°C (60°F) (H_2O = 1)
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not determined.

SECTION IV -- FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: 171°C (340°F) minimum. Cleveland Open Cup.
FIRE POINT: Not determined; Estimated to be 10 - 20 C° (18 - 36 F°) higher than flash point.
CONDITIONS OF FLAMMABILITY: Must be heated to sustain flames.
FLAMMABLE LIMITS IN AIR - LOWER: Not determined. (1% typical for petroleum product mists)
FLAMMABLE LIMITS IN AIR - UPPER: Not determined. (10% typical for petroleum product mists)
EXTINGUISHING MEDIA: Carbon Dioxide, Foam, Dry Chemical, Water Spray. Water jets or foam may cause frothing and cause material to spread.
FIRE FIGHTING PROCEDURES -- SPECIAL: Use self-contained breathing apparatus. Keep storage tanks cool using water spray.
UNUSUAL FIRE AND EXPLOSION HAZARDS: Decomposition and combustion products may be toxic. Heated tanks and drums may rupture, explode or be thrown into the air.
HAZARDOUS COMBUSTION PRODUCTS: Thermal decomposition and burning may produce carbon monoxide, carbon dioxide,

SECTION IV--FIRE AND EXPLOSION HAZARD DATA CONTINUED...

nitrogen oxides and other toxic organic species.
EXPLOSION DATA: Not sensitive to mechanical impact. Not sensitive to electrical discharge unless heated above flash point.

SECTION V -- REACTIVITY DATA

STABILITY: Stable
INCOMPATIBILITY: Strong oxidizing agents (e.g. chlorine, peroxides, strong acids).
HAZARDOUS POLYMERIZATION: Will not occur
HAZARDOUS DECOMPOSITION PRODUCTS: Carbon monoxide and other asphyxiants.

SECTION VI -- HEALTH HAZARD DATA

This Material Safety Data Sheet (MSDS) has been prepared in compliance with the United States Federal OSHA Hazard Communication Standard 29 CFR 1910.1200 and the Canadian Hazardous Products Act R.S.,c. H-3;1985

PRIMARY ROUTES OF EXPOSURE: Inhalation of oil mist possible under certain conditions of use; Skin contact; Eye contact; Low order of toxicity by all routes. This material as a whole has not been tested for all potential health hazards.
EXPOSURE LIMITS:
ACGIH TLV: TWA 5 mg/m^3: STEL 10 mg/m^3 for oil mists
OSHA PEL: TWA 5 mg/m^3
LD_{50}: > 5000 mg/kg body weight in rats estimated; oral and dermal
LC_{50}: Not determined
SENSITIZATION: Not applicable.
CARCINOGENICITY: This product has been tested for dermal carcinogenicity by the Sun Predictor Test and is predicted to be dermally non-carcinogen. This chemical is not considere to be carcinogenic by IARC, N or OSHA.
Note: Some lubricating oils m become carcinogenic after usa over a period of time. Observ proper personal hygiene.
SIGNS AND SYMPTOMS OF EXPOSUR
ACUTE:
Skin: May cause slight irritation but does not cause permanent damage. May result defatting, redness, itching, inflammation, cracking and possible secondary infection. Hot material may cause therma burns.
Eye: May cause slight irritat but does not cause permanent damage. Contact with hot material may cause thermal burns.
Inhalation: Exposure to high mist concentrations may lead oil pneumonia.
Ingestion: May cause nausea a vomiting. May act as a laxati May irritate gastrointestinal tract. Does not cause permane damage.
CHRONIC:
Inhalation: Exposure to high mist concentrations may lead oil pneumonia.
MEDICAL CONDITIONS AGGRAVATED EXPOSURE: Allergy, eczema or skin conditions.
REPRODUCTIVE TOXICITY: Not applicable.
TERATOGENICITY: Not applicabl
MUTAGENICITY: This product ha been tested by the Modified Salmonella Mutagenicity Assay and is predicted to be non-mutagenic.
TOXICOLOGICALLY SYNERGISTIC PRODUCTS: Not determined.

SECTION VII -- FIRST AID MEASURES

EMERGENCY AND FIRST AID PROCEDURES -- EYES: Flush eyes with water for 15 minutes or until irritation subsides. Get medical attention if irritation persists.
EMERGENCY AND FIRST AID PROCEDURES -- SKIN: Promptly remove from skin with dry cloth followed by thorough washing with mild soap and water. Treat burns from hot oil by running under cold water. Get medical attention if burns are serious.
EMERGENCY AND FIRST AID PROCEDURES -- INGESTION: Do not induce vomiting because of danger of aspirating liquid into lungs. If conscious, give large quantities of water or milk to dilute stomach contents. Do not attempt to give anything by mouth to an unconscious person. Get medical attention.
EMERGENCY AND FIRST AID PROCEDURES -- INHALATION: Remove to fresh air. Administer artificial respiration if breathing is stopped. Get medical attention.
EMERGENCY AND FIRST AID PROCEDURES -- OTHER: Remove and wash non-impervious contaminated clothing prior to reuse.

SECTION VIII -- PREVENTIVE MEASURES

SECTION VIII (a) -- SPILL OR LEAK PROCEDURES

SPILL PROCEDURES: If possible, contain as a liquid for possible re-refining. Absorb onto sand or other absorbent material. Shovel into closeable container for disposal. Wear protective equipment specified below. Contain away from surface waters and sewers.

WASTE DISPOSAL METHODS: Dispose in accordance with Federal, State, Provincial and local regulations. Contact manufacturer regarding recycling.

SECTION VIII (b) -- SPECIAL PROTECTION INFORMATION

VENTILATION: Local exhaust recommended where oil mist concentration exceeds TLV. Mechanical exhaust acceptable.
PROTECTIVE GLOVES: Wear impervious gloves. Neoprene or nitrile rubber recommended.
EYE PROTECTION: In cases where there is likelihood of eye contact, wear splashproof goggles.
RESPIRATORY PROTECTION: None required for normal conditions. Use approved equipment when exposed to oil mist concentrations above the personal exposure limit.
OTHER PROTECTIVE EQUIPMENT: Wear gauntlets and apron, especially for transfer of bulk quantities of product.

SECTION VIII (c) -- SPECIAL PRECAUTIONS

HANDLING PRECAUTIONS: Do not get in eyes, on skin or clothing. Do not inhale mists or heated vapors. Do not taste or swallow. Use with adequate ventilation. Wait for hot oil to cool before handling.
SHIPPING AND STORING PRECAUTIONS: Empty product containers may contain product residue. Do not reuse containers. Do not pressurize, cut, heat, weld, grind or expose containers to flame or other sources of ignition. Keep container tightly closed when not in use and during transport.

SECTION VIII (C) -- SPECIAL PRECAUTIONS CONTINUED...

PERSONAL HYGIENE: Wash thoroughly with soap and water after handling and before eating, drinking or using tobacco products.

SECTION IX -- REGULATORY INFORMATION

TDGA/DOT PROPER SHIPPING NAME: Not regulated as a hazardous material by either the U.S. Dept. of Transportation (DOT) 49 CFR 172.101 Hazardous Materials Table, or by the Canadian Dept.of Transportation's Transporation of Dangerous Goods Act.
TDGA/DOT CLASS: None.
TDGA/DOT NUMBER: None.
RCRA STATUS: Not a hazardous waste under RCRA (40 CFR 261).
TOSCA INVENTORY STATUS: Not prohibited under TOSCA regulations.
SARA Title III: Not listed.

SECTION X -- OTHER INFORMATION

In its expected use this product is not hazardous. If this material is used in applications where oil mists are produced the following information is relevant:

SPECIFIC CHEMICAL NAME: Spent Lube Oil, Hydrotreated..C15-C50
PERCENT: 100%
CAS REGISTRY: #64742-58-1
HAZARD: ACGIH TLV / OSHA PEL - Oil Mist
EXPOSURE LIMITS:
OSHA PEL: TWA 5 mg/m^3 for oil mists.
ACGIH TLV: TWA 5 mg/m^3: STEL 10 mg/m^3 for oil mists .

SECTION XI -- PREPARATION INFORMATION

PREPARED BY: BresLube WHMIS Group
ISSUE DATE: September 29, 19
REVISED: JANUARY 29 1990

Certificate of Analysis

SAFETY-KLEEN CANADA INC.
BRESLUBE DIVISION
300 WOOLWICH ROAD
BRESLAU, ON
27 Mar 1991

Our order #00104817-000
Our cust. #019902-045

for DIANE MCCURDY, CH2M HILL ENG.
SUITE 100 PLAZA 3
2000 ARGENTIA ROAD
MISSISSAUGA ON

Your PO #DALE O'DUFF

Product Certified : 00BR85XXHX 8P00L00E GE F/

Results from Certification Samples

Trailer 89- loading. Ref. #BR-55498

Viscosity @ 100 F SUS	85.6 SUS
Viscosity Index	87
Viscosity @ 100 C	3.44 cSt
Viscosity @ 40 C	15.77 cSt
Colour Index	L1.5
Specific Gravity @ 60 F	0.8649 sp.gr.86
Pour Point	-15 deg. C
Total Acid Number (mg KOH /g)	0.024 mg/g
Flash Point by Clevland Open Cup	190 deg. C
Demulsibility @ 54C Oil Phase	41 ml
Demulsibility @ 54C Water Phase	39 ml
Demulsibility Emulsion Phase	0 ml
Demulsibility @ 54C Time in minutes	5 min

Authorized Signature

Certificate of Analysis

SAFETY-KLEEN CANADA INC.
BRESLUBE DIVISION
300 WOOLWICH ROAD
BRESLAU, ON
27 Mar 1991

Our order #00104620-000 for DIANE MCCURDY, CH2M HILL ENG..
Our cust. #019902-045 SUITE 100 PLAZA 3
2000 ARGENTIA ROAD
MISSISSAUGA ON

Product Certified : 083R100X4X BRESLUBE 100 A

Results from Certification Samples

Trailer or Loading Ref. #BR-5E4S1

Viscosity @ 100 F SUS	105.5 SUS
Viscosity Index	99
Viscosity @ 100 C	3.97 cSt
Viscosity @ 40 C	19.95 cSt
Colour Index	L2
Specific Gravity @ 60 F	0.8676 sp.gr.@6
Pour Point	-12 deg. C
Total Acid Number (mg KOH /g)	0.01 mg/g
Flash Point by Clevland Open Cup	200 deg. C
Demulsibility @ 54C Oil Phase	43 ml
Demulsibility @ 54C Water Phase	37 ml
Demulsibility Emulsion Phase	0 ml
Demulsibility @ 54C Time in minutes	5 min

Authorized Signature Robin Angel